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THE COPEPOD CRUSTACEANS OF CHESAPEAKE BAY

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INTRODUCTION

SOURCE OF MATERIAL

In 1915–16 and 1920–21 the United States Bureau of Fisheries conducted a biological and hydrographic survey of Chesapeake Bay. During the latter period the survey was under the immediate direction of Dr. R. P. Cowles, of Johns Hopkins University, and the copepods then collected by him were separated from the rest of the plankton and turned over to the author for identification and study.[1]

The material included about one thousand two hundred 2-ounce bottles, with some of larger capacity up to 16 ounces. In sorting and identifying this large quantity of material the author was very ably assisted during the summer of 1923 by his son, John E. Wilson, who separated and counted the species in the various hauls and computed most of the percentages in the accompanying lists. The author identified the species and is entirely responsible for the text of the report.

COMPARISON WITH OTHER STUDIES

Among the numerous plankton studies that have appeared in recent years, especially those more immediately concerned with the free-swimming copepods, there are practically none whose subject material was derived from a source like Chesapeake Bay. The copepod fauna of many bays and gulfs has been studied, at times with considerable intensity, as in the case of the Gulf of Naples, Liverpool Bay, and the Bay of St. Andrews in Europe, and the Gulf of Maine and Narragansett Bay on the North American coast. Such gulfs and bays, however, are little more than partially restricted bodies of salt water, and not enough fresh water enters them to exert an appreciable influence.

[1] The results of the study as a whole have been published by the Bureau of Fisheries as follows: Cowles, R. P., A Biological Study of the Offshore Waters of Chesapeake Bay, Bull. Bur. Fisheries 46 (Fisheries Doc. 1091), pp. 277–381, 16 figs., 1930.

Excellent work has been done by Thomas Scott upon the Firth of Forth and by Giesbrecht on the Kieler Foehrde. But even these, while subject to vigorous tidal fluctuations, do not receive a sufficient influx of fresh water to modify sensibly their salinity and temperature. The rivers entering them are few and comparatively small, and the volume of water that they contribute is absorbed and neutralized almost immediately.

PECULIAR CONDITIONS OF CHESAPEAKE BAY

Chesapeake Bay differs from all that have been mentioned and from most other bays in the world in several particulars, which become of vital importance when considering its plankton.

Size.—Chesapeake Bay extends almost exactly north and south and in length covers 2¾° of latitude, or approximately 200 miles. Its width varies from a few miles near the upper end to 30 miles or more near the mouth of the Potomac River.

Depth.—Chesapeake Bay, according to geologists, is a submerged river mouth; that is, all the rivers of eastern Virginia and inner Maryland formerly united in a common trunk river which flowed across the present coastal plain and a part of what is now the continental shelf. During the subsequent depression of the Atlantic coast the lower valleys of this river system were submerged to form Chesapeake Bay. Hence it is comparatively shallow over the greater portion of its area, from 10 to 20 meters deep. At only four localities did the depth exceed 30 meters, and at only four others did it fall below 10 meters. Notwithstanding its great size, therefore, it becomes quite susceptible to the influx of fresh water by reason of its shallowness.

Tributaries.—Six large rivers flow into the bay, one at the extreme upper end, the others along the western shore. These include three of the longest rivers east of the Alleghenies—the Susquehanna, the Potomac, and the James. The other three, the Patuxent, the Rappahannock, and the York, are shorter. Among the small rivers may be mentioned the Patapsco and the Gunpowder, entering the bay from the west, and the Elk, the Chester, the Choptank, the Nanticoke, the Wicomico, and the Pocomoke from the east. In addition to these are a multitude of tiny rivers, streams, creeks, and runs, all of which contribute to increase the quantity of fresh water poured into the bay. The combined result is a volume amply sufficient to modify materially the water of the bay, and to transform it into an ever-changing mixture of salt and fresh water.

Salinity.—Since fresh water is lighter than salt water, it has a tendency to remain near the surface, while the heavier salt water stays near the bottom. There are thus produced remarkable differences in

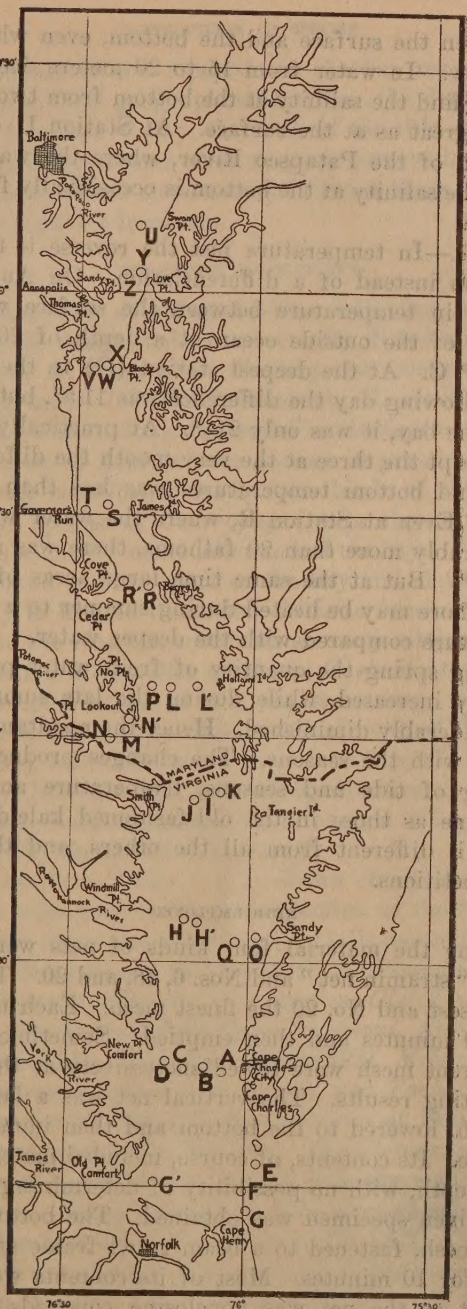

FIGURE 1.—Chesapeake Bay biological and hydrographic stations, 1915–16 and 1920–21. Map from Fisheries Document 1091, reproduced by courtesy of the Bureau of Fisheries.

salinity between the surface and the bottom, even where the water is very shallow. In water from 15 to 20 meters deep it is not at all unusual to find the salinity at the bottom from two to two and a half times as great as at the surface. At Station U (fig. 1), opposite the mouth of the Patapsco River, where the water is only 11 meters deep, the salinity at the bottom is occasionally four times that at the surface.

Temperature.—In temperature just the reverse is true: There is an equalization instead of a differentiation. On August 21, 1920, the difference in temperature between the surface water and the bottom water of the outside ocean at a depth of 20 fathoms was more than 16° C. At the deepest station (G) in the mouth of the bay on the following day the difference was 11.5°, but at Station B, 20 miles up the bay, it was only 2½°. At practically every station in the bay except the three at the very mouth the difference between the surface and bottom temperatures was less than 2° and often less than 1°. Even at Station R, where the water was 47.5 meters deep, considerably more than 20 fathoms, there was a difference of less than 1½°. But at the same time large areas of very shallow water along shore may be heated during summer to a comparatively high temperature compared with the deeper water.

Also, during spring the quantity of fresh water poured into the bay is greatly increased, while during the late summer and early fall it is considerably diminished. Hence the resultant combinations vary greatly with the seasons. The changes produced by all this intermingling of tide and seasons, temperature and salinity are much the same as those in the old-fashioned kaleidoscope. Each combination is different from all the others, and there are never any exact repetitions.

NETS EMPLOYED

In collecting the material four kinds of nets were used, called, respectively, "stramin net" and Nos. 6, 18, and 20. The stramin net had the coarsest and No. 20 the finest mesh. Each net was usually towed for 10 minutes and then emptied. Sometimes two or three nets of different mesh were towed successively at the same station with contrasting results. The vertical net was a large tow net of medium mesh, lowered to the bottom and then immediately drawn to the surface. Its contents, of course, included material from every stratum of depth, with no possibility of determining the level from which any given specimen was obtained. The bottom net was one of medium mesh, fastened to a beam trawl frame and towed along the bottom for 10 minutes. Most of its contents would be bottom material, but as the net was nonclosing copepods could get into it while it was being lowered and raised.

DISTRIBUTION OF SPECIES

The distribution of the copepods in the bay may be considered with reference to their geographical location, the depth and salinity of the water, the time of day, the state of the tide and the kind of bottom, and the time of year when they are present in greatest abundance. It will be found convenient to discuss these different points of view under separate headings.

GEOGRAPHIC DISTRIBUTION

Species universally distributed.—The following 10 species (see Table 1) may be designated as universally distributed in the bay: *Acartia clausii*, *A. longiremis*, *Centropages hamatus*, *C. typicus*, *Harpacticus gracilis*, *Oithona brevicornis*, *O. similis*, *Paracalanus parvus*, *Pseudocalanus elongatus*, and *Pseudodiaptomus coronatus*.

The two species of *Acartia* were present in practically every haul, and numerically constituted nearly two-thirds of the entire collection. The two species of *Centropages* were absent from comparatively few hauls, chiefly at the inner end of the bay. The *Harpacticus* species was found in every part of the bay and at 23 of the 31 stations, but only in limited numbers. *Oithona brevicornis* was nearly as universal as the *Acartia*, occurring at every station except U, but nearly always in much smaller numbers; *O. similis* was present at all the stations except four, but in even smaller numbers than *brevicornis*. The three remaining species were found at most of the stations, but seldom did they constitute more than 1 or 2 per cent of the total. *Microthalestris littoralis* was also widely distributed throughout the bay but in such small numbers and at so few (13) of the stations that it can hardly be classed as universal.

Inner-bay species.—Table 1 also shows 10 species that may be designated as belonging to the inner portion of the bay. The division between the inner and outer portions falls naturally at the Maryland-Virginia State line at the mouth of the Potomac River. These species are *Canuella elongata*, new species, *Cletodes longicaudatus*, *Dactylopusia brevicornis*, *Ectinosoma normani*, *Eurytemora americana*, *E. hirundoides*, *Harpacticus littoralis*, *Metacyclops gracilis*, *Robertsonia chesapeakensis*, new species, and *Tachidius littoralis*.

The new species of *Canuella* was obtained at Stations W and Z, near the extreme inner end of the bay. The *Cletodes* species was confined to Station R, off Barren Island, just above the mouth of the Patuxent River. *Dactylopusia* and *Ectinosoma* also occurred at single stations, the former at N′ and the latter at Y. The two species of *Eurytemora* were found very sparingly in the outer bay, but quite abundantly in the inner bay. *Harpacticus littoralis* was confined to Stations R′, S, and T. *Metacyclops gracilis* appeared in a single haul

TABLE 1.—*Seasonal distribution of copepods in Chesapeake Bay* [1]

SPECIES	STATION																													
	A	B	C	D	E	F	G	G′	H	H′	I	J	K	L	L′	M	N	N′	O	P	Q	R	R′	S	T	U	V	W	X	Y	Z
Acartia clausii [2]	E	E	E	E	E	E	E	E	E	E	E	E	E	VS	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E
Acartia longiremis [2]	E	E	E	E	E	E	E	E	E	E	E	E	E	VS	E	S	E	E	E	E	E	E	E	E	E	S	E	E	E	W	W
Alteutha depressa [3]						W		W																							
Amallophora brevicornis [2]																															
Anomalocera patersoni [2]																															
Bomolochus eminens [3]																				S											
Calanus finmarchicus [2]	W	W			W	W	S		W	W	W	W																			
Calanus helgolandicus [2]																															
Caligus schistonyx [3]			A				A																								
Candacia armata [2]																								V							
Canuella elongata [3]																												S			V
Centropages bradyi [2]																															
Centropages hamatus [2]	W	W	SA	W	SW	SW	W	W	W	W	SW		S	V	S	W	W	W	W	W	W	V	V	V	V		V	S	W		
Centropages typicus [2]	W	W	SW	W	SW	W	W	W	W	W	W		AW	V	W		W	W	W	W	A	W	W	WV	W				W	W	V
Cletodes longicaudatus [3]																						W									
Clytemnestra rostrata [2]																															
Corycaeus elongatus [2]			A																												
Corycaeus lubbockii [2]																															
Corycaeus robustus [2]																															
Corycaeus rostratus [2]																															
Corycaeus speciosus [2]																															
Corycaeus venustus [2]		A	A		W	A																									
Corycella carinata [2]							W																								
Cryptopontius gracilis [3]	W																														
Dactylopusia brevicornis [3]																		W													
Diosaccus tenuicornis [3]						W																									
Ectinosoma curticorne [3]	W	S					W	W			S							W	V		W		S	S	V		W	W	W	W	WV
Ectinosoma normani [3]																														W	
Euchaeta norvegica [2]																															
Eurytemora americana [3]					W		W																W	W	W		W	V			V
Eurytemora hirundoides [3]					S		W		W				W			W	V	W		V	W		W		W		V	V	S	V	V

Harpacticus chelifer [3]							W																								
Harpacticus gracilis [2]	W					W	W	W	WV		W		S		S	W	W	W	V	W	A	W	W	W		S	W	V	W	V	W
Harpacticus littoralis [3]																							W	A	W						
Hemicyclops americanus [3]																							S					V			
Labidocera aestiva [2]	SA	AW	A	S	W	W	A	W	SW	SA	A		A		A		A		A	A	A									W	
Labidocera wollastoni [3]							S																								
Macrosetella gracilis [2]																															
Mecynocera clausii [2]																															
Metacyclops gracilis [3]																															A
Metridia lucens [2]																															
Microsetella norvegica [3]					W	W																									
Microthalestris littoralis [3]	W		S			A		W			V	S					W	W	V		W	V			V						V
Oithona brevicornis [2]	SA	AW	SA	A	W	W	S	SW	S	S	W	SA	W	S	S	W	S	W	VS	S	V	S	VW	S	V		V	V	W	V	V
Oithona plumifera [2]																															
Oithona similis [2]	W	W	A		SW	AW	W	W		S	W	S	W	V	AW		W	W	S	W	W	AW	W	A	W		W	AW	W	W	W
Oithona spinirostris [2]							W																								
Oncaea minuta [2]			S		A	S									S																
Oncaea venusta [2]																															
Paracalanus parvus [2]	A	A	S	S	AW	AW	AW	VW	S	SA	SA	S	W	V	A	S	S	A	VS	S	A	A	W	S			W	W	W	W	W
Pontella atlantica [2]																															
Pontella meadii [2]	W					SA													S		S										
Pontella pennata [2]			S																												
Pseudocalanus elongatus [2]	W	W			SW	S	S	W	W	A				V		SW	A		S		A	V	V				V	V		W	V
Pseudodiaptomus coronatus [2]	WV	AW	W	W	S	W	S	W	W	A	W		W		S	W	A	W	A	W	A	W	W	W	W		WV	V	W	W	W
Rhincalanus nasutus [2]																															
Robertsonia chesapeakensis [3]																									V						
Sapphirina gemma [2]																															
Sapphirina sinuicauda [2]																															
Tachidius littoralis [3]															A			W													
Temora discaudata [3]			A			A																									
Temora longicornis [2]					W	W	W																							W	
Temora turbinata [3]		A		A	W	W	A	W													A										
Tisbe furcata [2]								V																							

[1] A=autumnal; E=entire year; S=summer; V=vernal; W=winter. E (entire year) based upon records taken during July, August, October, and December, 1920, and January, March, April, May, and June, 1921, with the other three months missing. The species taken on the trip to the 100-fathom line are simply designated (footnote 2) as present in the ocean, since they were taken but once in August, and there are no data to tell when they are the most abundant.

[2] Present in the ocean.

[3] Found in the bay only.

at Station Z, the new species of *Robertsonia* in a single haul at Station T, and *Tachidius littoralis* in single hauls at Stations L′ and N′.

Outer-bay species.—In contrast with the littoral species just enumerated, 16 others may be regarded as belonging to the outer portion of the bay. These are *Alteutha depressa*, *Calanus finmarchicus*, *Corycella carinata*, *Corycaeus elongatus*, *C. venustus*, *Cryptopontius gracilis*, *Diosaccus tenuicornis*, *Harpacticus chelifer*, *Labidocera wollastoni*, *Microsettella norvegica*, *Oithona spinirostris*, *Oncaea minuta*, *Pontella meadii*, *Temora longicornis*, *T. turbinata*, and *Tisbe furcata*.

Eight of these species were confined to single hauls at different stations, two appeared at two stations each, and three at four stations each. Of the remaining species, *Calanus* occurred fairly abundantly in the wider portion of the bay below the mouth of the Potomac River. The first species of *Temora* was found at the three stations in the mouth of the bay and also at Station Y near the extreme inner end of the bay. The other species, *Temora turbinata*, was most abundant at the mouth of the bay and only went up as far as the mouth of the Rappahannock River.

The parasitic species, *Bomolochus eminens*, was found in the adult stage only at Station P in the inner bay, but development stages were very common at nearly every station in the outer bay. The geographic location of these parasites, however, is determined by the distribution of their hosts rather than by any locality where they happen to be captured swimming freely in the tow.

Oceanic species.—A fourth division would include such species as were not found at any of the stations within the limits of the bay, but were present more or less abundantly in the outside ocean. There are 19 such species, and they will be found discussed on page 16 under the trip to the 100-fathom line.

SALINITY DISTRIBUTION

The salinity records made during the investigation vary all the way from 31.74 per cent on the bottom at Station G in the mouth of the bay down to 4.75 on the surface at Station U, the innermost station opposite the mouth of the Patapsco River. If we recall, in connection with this remarkable range in salinity, what has already been said with regard to the kaleidoscopic changes produced by the tides and the seasons, certain deductions naturally follow:

1. The 10 species universally distributed, especially the two Acartias and *Harpacticus gracilis*, must be able to accommodate themselves to great and fairly rapid changes in salinity. The three species mentioned were taken in surface hauls at Stations G and U, and the two Acartias also appeared in the bottom hauls. The depth

at Station U was only 11 meters, but the bottom salinity was about three times that at the surface. If these species migrate daily up and down as they are known to do elsewhere, the change in salinity must be more or less abrupt in so short a distance.

2. The 10 copepods found exclusively or most abundantly in the inner bay may be regarded as brackish-water species, since they were found in water with an average salinity of 15 per cent or less. They also are probably able to accommodate themselves to rapid changes in salinity, especially to those involving reduction.

3. The 16 species found exclusively in the outer bay may be regarded as salt-water forms. They were found in water with a salinity ranging between 20 and 30 per cent, and the changes are not so great as for the other two groups.

4. The 14 species confined to single areas in the bay will be considered separately, since salinity may have been one of the factors determining their distribution. Table 2 gives the complete statistics with reference to these species and will serve for the other aspects of distribution as well as for that of salinity.

The *Cletodes* species has been recorded from various European localities, all of which were considerably farther north. No record of the salinity of the water in which the specimens were found has been given, but judging from the localities it seems probable that it was higher than that here recorded. The single species of each of the genera *Corycaeus*, *Corycella*, *Diosaccus*, *Harpacticus*, and *Oithona*, together with the new species of *Pontella*, were all taken in water of normally high salinity, between 25 and 30 per cent. Giesbrecht described four species of *Cryptopontius* from the Bay of Naples, and Sars reported one of them from the south coast of Norway. They were all bottom forms, but nothing was said about the salinity of the water in which they were found. The new species here recorded comes also from the bottom at one of the deepest stations near the mouth of the bay, where the salinity is fairly high. *Ectinosoma normani* was first recorded from the Firth of Forth in Scotland and afterwards from Vadso, Finmark, and the upper part of the Christiania Fiord in Norway, from a depth of 6 fathoms on a muddy bottom. The present specimens came from near the inner end of the bay, at about twice the depth (20 meters) on a muddy bottom where the salinity was low. The *Labidocera* species has been reported by Giesbrecht from the Atlantic Ocean between latitude 36° and 55° N. The mouth of the bay where the present specimens were obtained is on the parallel of latitude 37° N., and the salinity is but little less than that of the open ocean. *Metacyclops* is a fresh-water copepod, found in lakes and rivers all over the world. Here it was obtained just below the mouth of the Patapsco River,

TABLE 2.—*Complete statistics of species of copepods confined to single stations*

Species	Station	Date	Time	Tide	Temperature	Bottom	Depth	Salinity	Net
					°*C.*		*Meters*	*Per cent*	
Cletodes longicaudatus	R	Dec. 8, 1920	3 p. m.	¾ flood	+9.9	Mud, sand	47.5	19.85	Bottom.
Corycaeus elongatus	C	Oct. 20, 1920	5.40 p. m.	¾ flood	+19.5	Mud, gravel, sand	12.5	26.44	Bottom.
Corycella carinata	G	Dec. 4, 1920	4.45 p. m.	¾ flood	+11.6 av.	Mud, sand	23	25–30.9	Vertical.
Cryptopontius gracilis	A	Dec. 5, 1920	10.40 a. m.	¼ flood	+10.3	Mud, sand	46	23.96	Bottom.
Dactylopusia brevicornis	N′	Dec. 7, 1920	8.45 a. m.	¼ flood	+8.9	Mud	10.5	15.61	Surface.
Diosaccus tenuicornis	F	Dec. 4, 1920	6 p. m.	Full flood	+10.8 av.	Mud, sand	16	26.53 av.	Vertical.
Ectinosoma normani	Y	Jan. 27, 1921	12.45 p. m.	¼ ebb	+3.8	Mud	20	14.46	Bottom.
Harpacticus chelifer	G	Dec. 4, 1920	4.45 p. m.	¾ flood	+10.5	Mud, sand	23	25.20	Surface.
Labidocera wollastoni	G	Aug. 22, 1920	10.40 a. m.	½ ebb	+27	Mud, sand	23.5	22.73	Surface.
Metacyclops gracilis	Z	Oct. 17, 1920	8 a. m.	¼ flood	+19.5	Mud	13	10.42	Surface.
Oithona spinirostris	G	Dec. 4, 1920	4.45 p. m.	¾ flood	+10.5	Sand, mud	23	25.20	Surface.
Pontella pennata	C	Oct. 20, 1920	5.40 p. m.	¾ flood	+19.5	Mud, gravel, sand	12.5	26.44	Bottom.
Robertsonia chesapeakensis	T	Mar. 29, 1921	4.10 p. m.	Flood	+9.9	Mud, sand	10	11.50	Bottom.
Tisbe furcata	G′	Dec. 4, 1920	12.30 p. m.	Full ebb	+9.6	Sand, mud, shells, clay	28	14.78	Surface.

where the salinity was very low. It was probably swept down by the current from the river into the bay. The new species of *Robertsonia* was captured in the upper central portion of the bay in water that had a depth of 9 meters over a muddy bottom, where the salinity was only 11.5. The type species of the genus has been reported by Brady and Scott from various localities around the British Isles, and by Sars from the upper part of the Christiania Fiord, but no data were given on salinity.

In general, therefore, eight of these species confined to single stations compare favorably with those from other regions in depth, salinity, and kind of bottom. In the case of five of the other species the salinity is presumably lower than that of the water from which they have previously been recorded. The remaining species, the fresh-water form, has been explained above.

SEASONAL DISTRIBUTION

In Table 1 the seasonal distribution is given for all the species obtained in the bay, the letters denoting the seasons of the year when the species was obtained in greatest abundance at the respective stations. In determining abundance, consideration must be given to both the percentage of the catch and the total number of specimens obtained. Five per cent of a catch totaling 10,000 specimens is manifestly a larger number than 80 per cent of a catch totaling 500 specimens, although at first it may appear much smaller. It is freely admitted that the seasonal abundance of any species at a given station may be largely modified by accidental or exceptional conditions, but when the records of all the stations at which the species was obtained are compared the information becomes fairly reliable. The more universally the species is distributed throughout the bay the more trustworthy become the inferences as to its seasonal distribution.

The two species of *Acartia* seem to have been equally distributed throughout the year. The total number of specimens was greatly increased during March and slightly during August. Two hauls, each totaling 100,000 specimens, and two of 25,000 each, were made during March, and these are the four highest totals obtained during the entire survey. These large hauls are the result, however, of the breeding season, which immediately preceded them, and in spite of the fact that they are made up almost entirely of the two *Acartia* species the latter are not to be regarded as spring copepods only. They were present everywhere in the bay throughout the entire year and always in large numbers. Williams reported *A. clausii* as most abundant in Narragansett Bay during January and February, and Fish listed it as one of the winter species at Woods Hole. These

four largest hauls were obtained in bottom nets near the inner end of the bay where the salinity was quite low.

The two species of *Centropages* were manifestly winter forms, since they were entirely lacking at many of the stations during the summer, and often early in autumn and late in spring. They appeared during the autumn, were present practically throughout the bay during the entire winter, and remained into the spring. *C. hamatus* continued into the summer in the outer bay, and at three stations there it was even recorded as most abundant during the summer. *C. typicus* was found by Fish to be a summer form at Woods Hole and *hamatus* a winter form. Williams also found the latter species at Narragansett Bay during January and February.

Harpacticus gracilis was also a winter form in the outer bay, but in the inner bay it continued into the spring, and some of the spring hauls yielded more specimens than those of the winter.

Labidocera aestiva was an autumn copepod, appearing in the inner bay only during October, except a few stragglers obtained in December. In the outer bay it was more abundant in winter but was occasionally found in summer. It was also obtained August 21, 1921, at depths of 40 and 67 fathoms in the outside ocean. It was given by Wheeler as common at Woods Hole during July and early in August. Fish included it in his list of Woods Hole species as "a southern oceanic form blown in by winds from the Gulf Stream during warm weather."

Oithona brevicornis was fairly well distributed throughout the year, but it may be called a summer form in the outer bay and a spring form in the inner bay. In the outer bay it also occurred abundantly during the autumn and winter, but in the inner bay it was often exclusively a spring form and was not found at all at other seasons of the year at many of the stations. The two largest hauls of this species totaled 2,000 specimens each and were made one at Station C in October and the other at Station F in December. Station F is one of the three in the mouth of the bay, and Station C is only a short distance inside.

In contrast with the preceding species, *Oithona similis* was a pronounced winter form in both portions of the bay, being confined at many stations exclusively to that season. It was occasionally found also during the summer and autumn, but every large haul was made during the winter. This species was found in small numbers by Wheeler at Woods Hole in July and by Williams at Wickford, R. I., in the summer. Fish listed both species of *Oithona* as summer forms for the Woods Hole region.

Paracalanus was most abundant in autumn in the outer bay, appearing late in summer and lasting into the winter. In the inner

bay it was more of a winter species and was found only during the winter at the stations of the extreme inner end of the bay. The largest number of specimens in any one haul was 1,500, obtained in October at Station H. The number of specimens of this species diminished steadily in going up the bay and toward the inner end were reduced so low as to be unworthy of a percentage mark, only one or two being found in some winter hauls. It was common both at the surface and probably near the bottom in the outside ocean during August.

Pseudocalanus was more of a winter species in the outer bay and a spring species in the inner bay. Its seasonal distribution, however, was not well defined anywhere, and it was apparently likely to appear in small numbers during any month of the year and in any part of the bay.

Pseudodiaptomus was a decidedly winter form throughout the bay. It was nowhere very abundant, but proved to be the exact reverse of *Paracalanus*, its numbers increasing in going up the bay and reaching their maximum at Station Z, with Station V a close second. In the outer bay its numbers were reduced below a percentage value at several stations. This species was reported as a summer form in Narragansett Bay by Williams and in the Woods Hole region by Fish. Fish stated, however, that it was not a true summer species, but served as a connecting link between the summer and winter copepods. Sharpe reported it from Sheepshead Bay, N. Y., in September. In Chesapeake Bay it seemed to appear in summer in small numbers, continued through the autumn, reached its maximum early in winter, and then lasted into early spring at a few stations.

The species thus far considered are the 10 that were universally distributed. Of the others *Calanus finmarchicus* appeared only in the outer bay and during the winter. It was found, however, in goodly numbers in the outside ocean during August.

Ectinosoma curticorne was a winter species, especially in the inner bay, where it was much more abundant than in the outer bay. *Eurytemora americana* was found only in winter, except at the extreme inner end of the bay, where it appeared in March at Stations W and Z. The second species, *hirundoides*, was obtained chiefly during winter in the outer bay and during spring in the inner bay. The number of specimens taken increased decidedly in going up the bay. Both species of this genus were obtained by Williams in Narragansett Bay, but he did not give the seasonal distribution. Sharpe found *hirundoides* at Woods Hole in July, while Fish listed it as a winter form continuing into the spring.

Microthalestris appeared during every season of the year in the outer bay but was confined to winter and spring in the inner bay.

Oncaea minuta proved to be a summer form, appearing only once during the autumn. It was also obtained in summer, both at the surface and at the bottom, on the 100-fathom line in the outside ocean. *Temora turbinata* was entirely confined to autumn and winter, and with a single exception was found only in the inner bay.

Among species restricted to a few localities *Alteutha depressa*, *Cletodes longicaudatus*, *Corycella carinata*, *Cryptopontius gracilis*, *Dactylopusia brevicornis*, *Diosaccus tenuicornis*, *Ectinosoma normani*, *Harpacticus chelifer*, *Microsetella norvegica*, *Oithona spinirostris*, and *Temora longicornis* were obtained only in winter. *Candacia*, *Robertsonia*, and *Tisbe* appeared in spring, *Canuella* and *Hemicyclops* late in spring and summer, *Corycaeus elongatus*, *Temora discaudata*, and *Metacyclops* in autumn, *Corycaeus venustus* three times in autumn and once in winter, *Harpacticus littoralis* once in autumn and twice in winter, *Labidocera wollastoni* and *Pontella pennata* once in summer, *Pontella meadii* once in winter and three times in summer, and *Tachidius* once in autumn and once in winter.

Fish has listed *Alteutha* and *Dactylopusia* as summer species and *Microsetella* and *Tisbe* as winter species in the Woods Hole region. The new species of *Pontella* is also found there very commonly in summer and early in autumn.

To summarize, there were 3 species taken only in the spring, 3 only in the summer, 4 only in the autumn, and 18 almost only in the winter. The remainder showed a mixed seasonal distribution, being often more abundant at one season in the outer bay and at another season in the inner bay.

BREEDING SEASONS

Considered as a whole, the copepods showed a well-marked rhythm of development, which probably recurs yearly but whose seasonal proportions may vary considerably from year to year. There were apparently four breeding seasons, which were grouped about the months of January, April, July, and October. Each season begins toward the last of the month preceding and continues into the month following.

The first evidence of these breeding seasons was found in the presence of egg cases upon the adult females. Among the specimens captured during each of these breeding seasons there were always some, and often many, bearing eggs. For the January period were found such females of the two species of *Acartia*, the two species of *Centropages*, *Eurytemora hirundoides*, *Oithona brevicornis* and *O. similis*, *Paracalanus* and *Pseudocalanus*, and the new species of *Cryptopontius*. During the April period were found egg-bearing females of *Ectinosoma curticorne*, *Microthalestris*, *Pseu-*

docalanus, and the new species of *Robertsonia*. For the July period females of the two *Acartia* species again appeared bearing eggs, together with *Oncaea venusta*, *Oithona brevicornis* and *O. similis*, *Microthalestris*, *Pseudodiaptomus*, and the new species of *Canuella*. During the October period eggs were found upon females of *Pseudodiaptomus*, *Oithona similis*, *Harpacticus gracilis*, *Ectinosoma curticorne*, *Labidocera aestiva*, *Temora turbinata*, and the two species of *Centropages*.

Other evidence of these four breeding periods was found in the large number of development forms, nauplii, metanauplii, and cyclops stages, captured with the adults during the month following each period. These development stages in the tow proved that the eggs hatched a short time previously.

The breeding periods caused rhythmic fluctuations in the total numbers of specimens captured in the tow. It has already been noted that the four largest hauls were made in March. It may now be added that all the hauls made during that month had exceptionally high totals of specimens, although the hauls themselves were few in number. This may be designated as the first, or spring, maximum, and was the result of the January breeding season combined with certain favorable conditions. Chief among the latter may have been the relative scarcity of the fishes and other animals that prey upon the copepods. The four largest hauls, those of Stations S, T, V, and Z, were made up practically entirely of the two *Acartia* species. The fish that feeds most upon these copepods is probably the shad, and as soon as it becomes numerous in the bay during spring the copepods probably diminish rapidly. Ten different stations in the bay were visited during March, and the average number of specimens obtained at each of them was 36,500. Eight of the same stations visited in June yielded an average number of specimens of only 1,150, or less than a thirtieth as much.

Thus the spring maximum was followed by a long decline, which was only slightly modified by the April breeding season, and which reached its lowest point, the year's minimum, in June. The July breeding season brought the number of specimens rapidly up again, and it was still further increased during the October breeding period. The records give the following statistics: During January, 29 stations showed a total of 120,200 specimens, an average of 4,145. During March, 10 stations gave a total of 365,200, an average of 36,520. Two stations in April gave a total of 5,175, an average of 2,587. The total of 8 stations in May was 30,150, an average of 3,769. In June, 13 stations yielded a total of 14,900, an average of 1,146. Twenty-nine stations in July gave a total of 75,400, an average of 2,600. In August, 97,350 specimens were taken at 29 stations, an

average of 3,357. In October, the total of 28 stations was 116,000, an average of 4,143. In December, 27 stations yielded a total of 129,350 specimens, an average of 4,791.

There were thus four rises and four falls during the year, corresponding to the four breeding periods, but the rise in March and that in the following fall were much greater than the others. The lowest minimum was found in June and was probably the result of the increased abundance of young fishes and other animals that prey upon the copepods.

No development stages were found at any of the stations near the inner end of the bay, but no positive statement can be made with reference to the ability of any of the copepods to breed in water of low salinity. The records do indicate, however, that water of higher salinity is more favorable for breeding purposes, since development stages practically disappeared at the mouth of the Potomac River, and were not found in any numbers above there except at Station T.

TRIP TO 100-FATHOM LINE

Supplementing the survey of the bay, a trip was made to the 100-fathom line on August 21, 1920, to ascertain which of the species found in the bay were also present in the outside ocean and what species, common in the outside ocean, did not enter the bay.[2] Hauls were made with surface and bottom nets at depths of 118, 67, 40, and 20 fathoms, and on the following day at a depth of 10 fathoms.

Forty-one species were collected during this trip, an exceptionally large number, but all of them except one or two were obtained in sufficient numbers to show that they were at least common. Nineteen species, designated in Table 3 by footnote 2, were not found inside the bay. The other 22 species were found both in the bay and in the ocean, and included every one of the 10 species that were universally distributed throughout the bay.

In contrast with this, 23 species, including all the new forms, were present in the bay but were were not found in the ocean. These are designated by footnote 3 in Table 1, giving the seasonal distribution of the species.

The species found in greatest numbers in the ocean proved to be *Centropages typicus*. Next to this came *Paracalanus parvus* and then in order *Calanus finmarchicus*, *Metridia lucens*, *Candacia*

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[2] In lieu of the original chart of the stations outside of Chesapeake Bay, which seems no longer to be extant, Dr. R. P. Cowles, in charge of the survey, has furnished the following information regarding their position:

"Our log shows that Station 8832 was on the 100-fathom curve where a line, run E. 5/8 S. from the whistle buoy 'F I R' off Cape Henry, cuts in. Stations 8833, 8834, 8835, and 8836 were on the 60, 40, 20, and 10 fathom curves, respectively, where the same line mentioned cuts them. I feel quite certain that the line follows the compass course."

TABLE 3.—*Record of trip to the 100-fathom line, August 21–22, 1920*

Time	5.40 p. m.		7.25 p. m.	9.00 p. m.		11.25 p. m.	6.00 a. m.	
Tide	¼ flood		½ flood	¾ flood		Slack flood	Ebb	
Salinity			29.7–34.4	29.9–33.3		29.7–33.5		
Depth	118 fathoms		67 fathoms	43 fathoms		20 fathoms	10 fathoms	
Net [1]	Surface	Bottom	Surface	Surface	Bottom	Bottom	Surface	Bottom
SPECIES COLLECTED	PER CENT OF TOTAL SPECIMENS							
Acartia clausii	5	2	5	2			30	5
Acartia longiremis	20		[3] T.				T.	
Amallophora brevicornis [2]		2						
Anomalocera patersoni [2]		T.						
Calanus finmarchicus		35						
Calanus helgolandicus [2]					20	20		
Candacia armata	T.	2		10	25			15
Centropages bradyi [2]	T.		T.		T.			
Centropages hamatus	10							
Centropages typicus	25	10	60	80	50	45		
Clytemnestra rostrata [2]	1		T.					
Corycaeus elongatus				T.				
Corycaeus lubbockii [2]	1							
Corycaeus robustus [2]	1	1						
Corycaeus rostratus [2]	1							
Corycaeus speciosus [2]	T.							
Corycaeus venustus	1	1						
Corycella carinata	1							
Euchaeta norvegica [2]		T.						
Harpacticus gracilis						3		
Labidocera aestiva			2	T.				
Macrosetella gracilis [2]			3					
Mecynocera clausii [2]		3						
Metridia lucens [2]		25			5		3	
Oithona brevicornis			3	2				5
Oithona plumifera [2]		3				5		
Oithona similis		2				5	5	55
Oithona spinirostris						2		
Oncaea minuta	1	3						
Oncaea venusta [2]	2	3	20				2	5
Paracalanus parvus	25	2	2	6		15	60	15
Pontella atlantica [2]		T.						
Pontella meadii	T.							
Pontella pennata, new species	T.							
Pseudocalanus elongatus		2				5		
Pseudodiaptomus coronatus	5		5					
Rhincalanus nasutus [2]		T.						
Sapphirina gemma [2]		T.			T.			
Sapphirina sinuicauda [2]		1						
Temora longicornis	1							
Tisbe furcata		3						
Total number of specimens	5,000	5,000	3,000	5,000	2,000	2,000	500	100

[1] 30-minute towings.

[2] Found only in the outside ocean.

[3] T.=trace.

armata, and the two species of *Acartia*, with *A. longiremis* more abundant than *A. clausii* at the 100-fathom line but less abundant nearer the shore. Of these seven species most abundant in the ocean, only one, *Metridia lucens*, was not also found in the bay.

The other oceanic species require but little comment. *Calanus helgolandicus* was present in considerable numbers in the bottom nets hauled from depths of 40 and 20 fathoms. The *Corycaeus* species are minute and appeared only in the surface net at the 100-fathom line. *Macrosetella gracilis*, *Euchaeta norvegica*, *Mecynocera clausii*, *Oithona plumifera*, and *Rhincalanus nasutus* are all oceanic forms not likely to be found in the bay unless at the mouth. *Candacia armata* might properly be included with these oceanic species, since it was found in the 10, 40, and 100 fathom hauls. The few specimens obtained in one of the bottom nets at Station S in the inner bay were evidently exceptional.

The fact that three of the *Corycaeus* species were found in the outer bay suggests that it is not impossible for some or all the other three species to appear there in the future. The new species of *Pontella* is evidently a northern form since it has been taken abundantly in surface tows at Woods Hole, Mass., during the summers of 1923 and 1924. *Clytemnestra*, *Euchaeta*, *Mecynocera*, *Metridia*, *Oithona*, *Rhincalanus*, and *Macrosetella* are all widely distributed and are found in the Pacific as well as in the Atlantic Ocean. *Oncaea* and the two *Sapphirina* species are not so cosmopolitan, but the former genus and *Sapphirina gemma* have been found on our Atlantic coast as far north as Marthas Vineyard.

Some of these oceanic species have not been reported before from our American coasts, and others have not previously been found as far south as the mouth of Chesapeake Bay. These will each be noted under the remarks given for the separate species in the following pages.

DISCUSSION OF THE SPECIES

The classification of the Copepoda proposed by Sars appears to be the simplest and most rational one thus far advanced. Accordingly the species are here arranged in the four groups, or suborders—Calanoida, Harpacticoida, Cyclopoida, and Caligoida—but since this is an account of the species found in a definite locality and not a systematic treatise, it seems wise to arrange the species in each group alphabetically and to omit family, generic, and specific diagnoses, except for new species or for those especially figured.

Suborder CALANOIDA

ACARTIA CLAUSII Giesbrecht

Acartia clausii GIESBRECHT, Fauna und Flora des Golfes von Neapel, vol. 19, Pelagische Copepoden, p. 507, pls. 30, 42, and 43, 1892.
Acartia clausi G. O. SARS, Crustacea of Norway, vol. 4, p. 150, pl. 101, 1903.

Occurrence.—Taken at every station in the bay, in the surface, the bottom, and the vertical nets. Most abundant in March after the winter breeding season.

Remarks.—This species is undoubtedly the chief component of the copepod fauna of the bay. Repeated hauls by every kind of net used during the survey yielded no other Acartias except these. The proportion of the two *Acartia* species, however, usually averaged about 3 specimens of *clausii* to 2 of *longiremis*. *A. clausii*, therefore, occupies in Chesapeake Bay a position corresponding to that of *Calanus finmarchicus* in the Gulf of Maine and elsewhere along the northern Atlantic coast. The total numbers of specimens captured furnish a good idea of the absolute abundance of these two *Acartia* species in the bay. The great majority of these totals run into the thousands, 20 of them are 10,000 or more, and 2 of them were estimated at 100,000 each. And yet practically none of the nets was towed longer than 10 minutes.

In view of such large numbers, these two species very likely form the bulk of the plankton food supply in the bay. This fact necessarily gives them great economic value, and they should no longer be regarded as merely two species of minute crustaceans possessed of moderate scientific interest. They may well assume a place of vastly higher importance in the life of the bay and take their stand beside the shad and the oysters, and the crabs and the terrapin, as one of the valuable resources of the bay.

In a paper by Prof. Arthur Willey, of McGill University, on the distribution of free-living Copepoda in Canadian waters[3] it was said that the stomach contents of shad, caught at Scotsman Bay, Nova Scotia, was a copious chyme made up almost wholly of *Acartia clausii*. The presence of the shad in such abundance in the bay, therefore, may be directly the result of the abundance of food awaiting them there.

Sars said of this species that it seemed to be a more southern form than *longiremis*, and this assumption is fully borne out by a comparison of the relative abundance of the two species in the Gulf of Maine and in Chesapeake Bay. In the former locality *longiremis* is much more abundant than *clausii*, but in the bay the proportion is reversed. Farran reported the present species as taken all through

[3] Cont. to Biol., vol. 1 (new ser.), no. 16, pp. 305–334, 1923.

the year on the mackerel-fishing grounds of Ireland, but as becoming more numerous in autumn. He also said that *longiremis* was not found there at all, and hence did not share with *clausii* in furnishing food.

In a continuous collection of plankton from Liverpool to Quebec, made by W. A. Herdman in 1897, these two *Acartia* species were taken along the English and American shores but disappeared entirely in the open ocean. Hence they may be regarded as littoral rather than pelagic species, well suited to such a region as Chesapeake Bay.

ACARTIA LONGIREMIS (Lilljeborg)

Dias longiremis LILLJEBORG, De Crustaceis ex ordinibus tribus in Scania occurrentibus, p. 181, pl. 24, 1853.

Acartia longiremis G. O. SARS, Crustacea of Norway, vol. 4, p. 149, pls. 99, 100, 1903.

Occurrence.—Taken at every station in the bay, in the surface, the bottom, and the vertical nets; most abundant in March.

Remarks.—Sars, in the reference given above (p. 150), said of this species: "It is a true pelagic form, being often met with far out at sea, and at the very surface. Not unfrequently, however, it is brought by the current close to shore; and it is even often found in tidal pools together with *Paracalanus parvus* and *Temora longicornis*." Its abundant distribution in Chesapeake Bay shows also that it may become essentially a littoral form. Its presence there is not dependent upon currents or tide pools; it is indigenous to the bay and forms one of the two chief constituents of the copepod plankton. Furthermore, it is just as abundant in the brackish water of the inner bay as in the outer bay, the salinity of which is nearly as high as that of the ocean.

This species occupies a position next to *A. clausii* and shares with the latter its economic importance as a component of the plankton food supply. Though its proportion to *clausii* is usually that of the 2:3 ratio already mentioned, it frequently falls to 20, 10, or even 5 per cent. Usually, however, it maintains a good average, and rarely it exceeds the former species in numbers.

AMALLOPHORA BREVICORNIS G. O. Sars

Scolecithrix brevicornis G. O. SARS, The Norwegian North Polar Expedition, Crustacea, p. 46, pl. 10, 1900.

Amallophora brevicornis G. O. SARS, Crustacea of Norway, vol. 4, p. 53, pl. 36, 1902.

Occurrence.—Obtained only in the bottom net at the 100-fathom line in the ocean outside the bay.

Remarks.—A pelagic form not likely to be found in the bay but not before reported from American shores.

ANOMALOCERA PATERSONI Templeton

Anomalocera patersoni TEMPLETON, Trans. Ent. Soc. London, vol. 2, p. 35, pl. 5, figs. 1–3, 1837.—G. O. SARS, Crustacea of Norway, vol. 4, p. 139, pls. 92–94, 1902.

Occurrence.—A few specimens were obtained in the bottom net at the 100-fathom line in the outside ocean.

Remarks.—Wheeler remarked that it appeared at Woods Hole, Mass., only after stormy weather and prevailing southwest winds. If it could be blown in there from the Gulf Stream, it might be carried into Chesapeake Bay from the 100-fathom line. Brady said that it is generally distributed over the Atlantic Ocean and the North Sea, as well as in the Mediterranean, and that it often occurs in large numbers.

CALANUS FINMARCHICUS (Gunnerus)

Monoculus finmarchicus GUNNERUS, Acta Hafnia, vol. 10, p. 175, figs. 20–23, 1765.

Calanus finmarchicus G. O. SARS, Crustacea of Norway, vol. 4, p. 9, pls. 1–3, 1901.

Occurrence.—Confined to the outer bay and found there only during winter and mostly at the surface. Apparently abundant in the outside ocean during summer.

Remarks.—This very cosmopolitan and widely known species is extremely abundant on our Atlantic coast farther north. In the Gulf of St. Lawrence and the Gulf of Maine it constitutes the bulk of the plankton. At the latitude of the mouth of Chesapeake Bay (37° N.), it does not seem to be so abundant. The fact that it was found only in the outer bay and was confined to the winter season corroborates the opinion that it is essentially a northern form. The latitude of this bay is probably near the southern limit of its distribution on our Atlantic coast.

CALANUS HELGOLANDICUS (Claus)

Cetochilus helgolandicus CLAUS, Die frei lebenden Copepoden, p. 171, pl. 26, figs. 2–9, 1863.

Calanus helgolandicus G. O. SARS, Crustacea of Norway, vol. 4, p. 11, pl. 4, 1901.

Occurrence.—Found in considerable abundance in the bottom net from depths of 40 and 20 fathoms in the outside ocean.

Remarks.—Sars regarded this as more of a southern species than *C. finmarchicus*, and suggested that the two have generally been confused by various authors. He apparently succeeded in differentiating the two species, and his decision has been accepted by Scott and by Pearson but not by some other authors. Among the latter, With devoted a long discussion to the solution of the question

whether Sars was right or wrong in separating the species, but he finished without coming to any conclusion. The reasons given by Sars would seem fully as valid as those for many of the regularly accepted species.

CANDACIA ARMATA (Boeck)

Candace armata BOECK, Christiania Videnskebeliger Selskabet Forhandlinger, p. 39, 1872.
Candacia armata G. O. SARS, Crustacea of Norway, vol. 4, p. 135, pl. 91, 1902.

Occurrence.—Found at Station S in one of the two largest hauls made in the bay, with a bottom net on March 29 in water 23 meters deep. Fairly common in the outside ocean.

Remarks.—This copepod was captured both at the surface and in the bottom net in the outside ocean. It is rather remarkable that it should have been captured but once within the bay and then so far above the center. It would seem as if it might be found some time at other places, especially in the outer bay.

CENTROPAGES BRADYI Wheeler

Centropages bradyi WHEELER, Bull. U. S. Bur. Fisheries, vol. 19, p. 174, fig. 12, 1900.—SHARPE, Proc. U. S. Nat. Mus., vol. 38, p. 406, 1911.

Occurrence.—A few specimens were obtained in the surface net over a depth of 118 and 67 fathoms, and in the bottom net towed at a depth of 40 fathoms during the trip to the 100-fathom line. It was not found anywhere within the limits of the bay.

Remarks.—The species was established by Wheeler upon numerous specimens of both sexes, which he considered identical with the ones described by Brady under the name *Centropages violaceus* (Claus).[4] This identification appears indisputable, and the range of the species on our American shores is here extended southward to Chesapeake Bay.

CENTROPAGES HAMATUS (Lilljeborg)

Ichthyophorba hamata LILLJEBORG, De Crustaceis ex ordinibus tribus in Scania occurrentibus, p. 185, pl. 21, figs. 9–12, 1853.
Centropages hamatus G. O. SARS, Crustacea of Norway, vol. 4, p. 76, pl. 52, 1902.

Occurrence.—Universally distributed throughout the bay and found at every station except U and Z. Appearing most abundant during winter in the outer bay and during spring in the inner bay. Taken indiscriminately in surface, bottom, and vertical nets, and present also in the outside ocean.

Remarks.—This species was given by Fish as one of the three typical winter forms at Woods Hole, and he added that the development

[4] Report on the *Challenger* Expedition, vol. 8, pt. 23, Copepoda, p. 83, pl. 27, 1883.

stages became so abundant in January and February as to far outnumber the adults. Probably some of the development stages noted during the present survey at various stations in the outer bay during winter belonged to this species. Found by Sars both in the Norwegian fiords and in the open ocean and believed to form an essential part of the food of several pelagic fishes, such as the herring and the mackerel. In Chesapeake Bay it is probably eaten also by the shad during their spring migrations.

CENTROPAGES TYPICUS Krøyer

Centropages typicus KRØYER, Naturh. Tidsskrift, vol. 2 (new ser.), p. 588, p. 6, figs. 22–26, 1847.—G. O. SARS, Crustacea of Norway, vol. 4, p. 75, pls. 49–51, 1902.

Occurrence.—Universally distributed throughout the bay and found at nearly every station. It is essentially a winter species but is probably present during the entire year. Like *C. hamatus* it was taken in surface, bottom, and vertical nets and was present in large numbers in the outside ocean.

Remarks.—Given by Fish as one of the two pelagic species that together form the bulk of the summer copepod fauna at Woods Hole. In Chesapeake Bay it is just as typically a winter form, but is apparently a summer species in the ocean outside the bay. Found in both the open sea and the fiords of the Norwegian coast, often in great abundance. Brady said that this species and *C. hamatus* were so common in the North Sea and the Atlantic that few gatherings were without them.

EUCHAETA NORVEGICA Boeck

Euchaeta norvegica BOECK, Christiania Videnskebeliger Selskabet Forhandlinger, p. 40, 1872.—G. O. SARS, Crustacea of Norway, vol. 4, p. 38; pls. 24–26, 1902.

Occurrence.—A few females of this species were taken in the bottom net on the 100-fathom line in the outside ocean, but it was not found anywhere within the bay.

Remarks.—This is a northern pelagic species and according to Bigelow occurs in most horizontal hauls deeper than 100 meters, but only sporadically at higher levels. Probably the present record is as far south as it has been obtained, and as it is an inhabitant of deep water there is little likelihood that it will be found within the bay. Sars found it particularly in the great depths of the fiords, and probably one condition that keeps it from entering the bay is the shallowness of the water. It is also possible that this copepod can not accommodate itself as readily as some others to any considerable change in salinity.

EURYTEMORA AMERICANA Williams

Eurytemora americana WILLIAMS, Amer. Nat., vol. 40, p. 645, figs. 8–11, 1906.

Occurrence.—Found at two stations at the mouth of the bay and at six stations in the inner bay, but not taken in the outside ocean. Not an abundant species and confined to winter and early in spring.

Remarks.—Not recorded by any author since Williams, 1906. In the present survey only a few specimens were obtained at the mouth of the bay, but about 150 were taken in each of two hauls with a bottom net in the inner bay, in 9 or 10 meters of water over a muddy bottom. Two other species of this genus were mentioned by Professor Willey as important factors of the stomach contents of shad caught in Nova Scotia waters. If the shad there consume the local species of *Eurytemora*, there is no reason why they should not do the same in Chesapeake Bay.

EURYTEMORA HIRUNDOIDES (Nordquist)

Temorella affinis var. *hirundoides* NORDQUIST, Die Calaniden Finlands, p. 48, pl. 4, figs. 5–11, pl. 5, fig. 5, 1888.

Eurytemora hirundoides G. O. SARS, Crustacea of Norway, vol. 4, p. 102, pl. 69, 1902.

Occurrence.—Widely distributed in the inner bay, but only sparingly in the outer bay; found most abundant at Station Z in water 13 meters deep on a muddy bottom. In three hauls made on March 27, 1921, it formed 25 per cent of the surface net total, 20 per cent of the vertical net total, and 15 per cent of the bottom net total estimated at 100,000 specimens.

Remarks.—This is a brackish-water species, which explains why it is so much more numerous in the inner bay. Its abundance there makes it one of the most important constituents of the plankton.

LABIDOCERA AESTIVA Wheeler

Labidocera aestiva WHEELER, Bull. U. S. Bur. Fisheries, vol. 19, p. 178, fig. 16, 1900.

Occurrence.—Distributed universally in the outer bay, sparsely in the inner bay, captured usually in the bottom net, but taken also at the surface. Most abundant in autumn, especially in the inner bay, but present also in summer and winter in the outer bay and at the surface of the outside ocean during summer.

Remarks.—This copepod was recorded by both Wheeler and Fish as a summer form at Woods Hole, whence its specific name. In Chesapeake Bay it is just as distinctly a winter and autumn species. It was found in sufficient numbers in the outer bay to constitute an important factor of the plankton, but in the inner bay it occurred so sparingly that it was seldom credited with a percentage mark.

LABIDOCERA WOLLASTONI (Lubbock)

Pontella wollastoni LUBBOCK, Ann. Mag. Nat. Hist., ser. 2, vol. 20, p. 406, pls. 10, 11, 1857.

Labidocera wollastoni G. O. SARS, Crustacea of Norway, vol. 4, p. 142, pls. 95, 96, 1902.

Occurrence.—Ten specimens of this species, including both sexes, were obtained in a surface net at Station G, August 22, 1920.

Remarks.—The single occurrence and limited number of this species make it a rare copepod in the plankton of the bay and of no economic value. It has never before, however, been reported from our American coast, as all Giesbrecht's specimens came from the western Atlantic. Sars considered it "like all the other Pontellidae, a true pelagic form, occurring more generally in the open ocean, close to the surface of the sea" (p. 143).

MECYNOCERA CLAUSII I. C. Thompson

Mecynocera clausii THOMPSON, Journ. Linnaean Soc. London, vol. 20, p. 146, pl. 11, figs. 1–4, 1888.—WHEELER, Bull. U. S. Bur. Fisheries, vol. 19, p. 168, fig. 5, 1899.

Occurrence.—About 150 specimens of this species were obtained in the bottom net at the 100-fathom line outside the bay.

Remarks.—This is another distinctly pelagic copepod and southern in its habitat. It is very transparent and colorless and is hence easily overlooked unless carefully searched for. The exceptionally long first antennae are very buoyant, and, when stretched out at right angles to the body axis, they hold the copepod in suspension, sometimes even after preservation. It is not likely to be found inside the limits of the bay. T. Scott[5] reported this copepod from 16 of the tow-net gatherings, the deepest of which came from a depth of 235 fathoms.

METRIDIA LUCENS Boeck

Metridia lucens BOECK, Christiania Videnskebelige Selskabet Forhandlinger, p. 238, 1864.—G. O. SARS, Crustacea of Norway, vol. 4, p. 113, pl. 77, 1902.

Occurrence.—Taken in large numbers in the bottom net during the trip to the 100-fathom line at depths of 40 and 118 fathoms.

Remarks.—Wheeler secured but a single specimen at Woods Hole in summer, but Fish found it a very common form in winter and spring. If it comes into the harbor at Woods Hole so freely at that season of the year, it would seem possible at least that it may enter the outer portion of Chesapeake Bay during the same season. This species is luminous and gives off a brilliant blue-green light when disturbed. During the spring before the summer plankton has

[5] Report on Entomostraca from the Gulf of Guinea, collected by John Rattray, B. Sc., Trans. Linn. Soc. London, ser. 2, vol. 6, pt. 1, Zoology, 161 pp., 15 pls., 1894.

developed, this copepod is one of the chief causes of marine phosphorescence. It was reported by Farran as forming with *Calanus finmarchicus* the main bulk of the tow on the Irish fishing grounds during spring and early summer, and as constituting an important factor in the food of the mackerel.

PARACALANUS PARVUS (Claus)

Calanus parvus CLAUS, Die frei lebenden Copepoden, p. 173, pl. 26, figs. 10–14; pl. 27, figs. 1–4, 1863.

Paracalanus parvus G. O. SARS, Crustacea of Norway, vol. 4, p. 17, pls. 8, 9, 1901.

Occurrence.—Found at every station in the bay except T and U, usually in considerable abundance in the outer bay, but gradually diminishing in numbers toward the inner end of the bay. Taken indiscriminately in surface, bottom, and vertical nets. Most abundant during autumn in the outer bay and during winter in the inner bay, but present everywhere throughout the year. Also found in large numbers in every haul but one during the trip to the 100-fathom line in the outside ocean.

Remarks.—Wheeler's record was the first for our American shores, and the present one carries the species as far south as the Chesapeake.

PONTELLA ATLANTICA (Milne-Edwards)

Pontia atlantica MILNE-EDWARDS, Histoire naturelle des Crustacés, vol. 3, p. 420, pl. 37, figs. 4–17, 1840.

Pontella atlantica, GIESBRECHT, Fauna und Flora des Golfes von Neapel, vol. 19, p. 461, pl. 24, figs. 1, 3, 13, 45, 49, 50; pl. 40, figs. 5, 8, 12, 13, 33, 41, 42, 1892.

Occurrence.—A few specimens of this species were taken in the bottom net at the 100-fathom line outside the bay.

Remarks.—This is another pelagic form and is not likely to be found within the limits of the bay. Although reported by many authors from the Atlantic Ocean, the localities given are all eastern, and it has not hitherto been found upon our American shores. It is the largest species of the genus and was given the specific name *magna* by Lubbock in 1853, and *gigantea* by Claus in 1863, both of which become synonyms of Milne-Edwards's name, given in 1840. Now that it has been found on this side of the Atlantic, this last name becomes even more appropriate. In spite of its size it has never been found in sufficient numbers to become of economic importance.

PONTELLA MEADII Wheeler

Pontella meadii WHEELER, Bull. U. S. Bur. Fisheries, vol. 19, p. 180, fig. 17, 1900.

Occurrence.—Numerous specimens of both sexes were taken in the surface and vertical nets at Station F, August 22, 1920, and in the bottom net October 21. A few others were obtained at Stations

A, O, and Q in surface and bottom nets; it was also present at the surface on the 100-fathom line.

Remarks.—Wheeler obtained only a few specimens in July and implied that they had been blown in from the southeast during a storm. Fish also recorded it as a summer form from the Gulf Stream. Its presence on the 100-fathom line at the latitude of Chesapeake Bay indicates that it is a southern form that occasionally gets as far north as Woods Hole. It has not thus far been found in the Gulf of Maine. It was found only in the outer portion of Chesapeake Bay during summer.

PONTELLA PENNATA, new species

PLATE 1

General characters.—This species closely resembles *P. meadii*, but the female can be readily distinguished from any other species of the genus, as well as from all free-swimming copepods, by the long pennon, or streamer, borne upon the last segment of the thorax, by the excessively short, 1-segmented abdomen, and by the minute non-plumose setae upon the caudal rami. The male is characterized by a long fingerlike process armed with spines and borne upon the anterior margin of the seventeenth [6] segment of the grasping antenna.

Specific characters of female.—Groove between head and first thoracic segment distinct; fourth and fifth thoracic segments separated, fourth segment with a rounded projection overlapping the fifth segment on the dorsal surface at the midline; fifth segment prolonged on each side into a broad and rather blunt point, nearly symmetrical. In addition to these usual lateral points this last segment has also two chitinous outgrowths. One of these is a thin lamella standing on edge along the midline on the dorsal surface just behind the projection from the fourth segment. It is crescent-shaped with the concave side toward the segment, the anterior point extending above the surface nearly to the posterior margin of the third segment. The posterior point is shorter but extends backward above the surface of the abdomen to the posterior margin of the latter. Being thus located on the midline and standing vertically, it is still symmetrical. The second outgrowth, however, is completely asymmetrical, being attached to the dorsolateral surface of the fifth segment, on the right side only and close to the lateral margin. It is also a thin lamina, which extends forward above the surface of the fourth and third segments nearly to the posterior margin of the second segment. It divides opposite the groove between the third and fourth segments into two parts. The portion nearest the body is short and

[6] According to Giesbrecht's numbering; in fig. D it is apparently on the twelfth segment.

rounded and curves inward toward the midline. The outer portion folds abruptly over dorsally and curves backward in a long pennon, or streamer, approximately parallel to the body axis, and nearly as long as the copepod itself. This streamer tapers gradually to a narrow point, and its edges are frayed into jagged teeth and fingerlike processes. These chitinous outgrowths make this species unique, although they are foreshadowed in a way by the asymmetrical processes in other species.

The antennae and mouth parts are similar to those of other species of the genus, with certain variations. Chief among the latter are the differences found in the chewing blade of the mandible. The drawing of this (pl. 1, G) shows that it is peculiarly powerful and armed with a row of formidable teeth. If its structure is any indication of habits this species must be very predacious, living upon all sorts of smaller creatures in the plankton. Its large size and its strong maxillae and maxillipeds enable it to seize and overpower these animals, which can then be chewed up by the mandibles. The fifth legs are much reduced in size and appear stunted when compared with those of *P. meadii*. The endopods are more than half the length of the exopods and end in two stout spines of approximately the same length.

Specific characters of male.—The male is slightly smaller than the female (A and C of Plate 1 are drawn to different scales). Its body is relatively thicker and its abdomen much longer, although still below the average for *Pontella* males. The lobes at the posterior corners of the last thoracic segment are distinctly asymmetrical, the right one being considerably longer and more sharply pointed. The abdomen, however, is practically symmetrical, but the last two joints are telescoped into the preceding joint so far as to be almost indistinguishable.

The right, or grasping, antenna is characterized by a long and stout fingerlike process projecting from the anterior margin of the seventeenth segment. This is armed along its outer margin with a row of four stout spines, which will at once distinguish this species from *meadii*, or indeed from any other species of the genus. One or two other species have such a process, but it is not armed with spines and is attached to a different segment. There is also a long and slender seta, or spine, on the fused thirteenth–fourteenth segment, similar to that in other species, but longer and hooked at the tip.

The second antennae and mouth parts are of the usual form; the fifth legs are very similar to those of the preceding species, but relatively much stouter, and the nonchelate ramus is considerably longer and armed with extra spines.

Color.—Somewhat like *meadii*, with a mid-dorsal row of dark spots, which are brown rather than black. In formalin specimens, the thickened portion of the grasping antenna of the male is a deep blue, almost purple. No blue or bluish-green markings appear anywhere else upon the body or appendages.

Measurements.—Female: Total length, 3 mm. to 3.5 mm.; greatest width at posterior margin of head, 1 mm.; length of posterior body, 0.125 mm. *Male:* Total length, 2.85 mm. to 3.25 mm.; greatest width at posterior margin of first thoracic segment, 1.1 mm.; length of posterior body, 0.5 mm.

Occurrence.—Several females were taken in a surface net on August 22, 1920, and in a bottom net on October 20, both at Station C. A few specimens were also captured at the surface on the 100-fathom line.

Types.—U.S.N.M. No. 58568, male, holotype; No. 63416, female, paratype.

Distribution.—Woods Hole (Fish).

Remarks.—Though this is probably a pelagic species, it comes into Woods Hole in considerable numbers during summer. It was obtained there in the tow during the summer of 1923, associated with *meadii*. It evidently enters Chesapeake Bay in a similar manner, since Station C is at least 20 miles inside the mouth of the bay, and there is no reason why it should not be found elsewhere in the outer bay. At first sight it might be supposed that the long chitinous streamer would hinder the activity of the female as compared with that of the male, or even with other copepods not thus burdened. But we do not find this to be true; the movements of the female are fully as energetic, and the resultant locomotion is as graceful and agile as if the body were without these chitinous outgrowths. It is very difficult to think of any way in which such outgrowths could be useful or protective to the copepod that bears them.

PSEUDOCALANUS ELONGATUS (Boeck)

Clausia elongata BOECK, Christiania Videnskebeliger Selskabet Forhandlinger, p. 234, 1864.

Pseudocalanus elongatus G. O. SARS, Crustacea of Norway, vol. 4, p. 20, pls. 10, 11, 1901.

Occurrence.—Universally distributed, but did not appear at 12 of the stations, 7 of which were in the inner bay. Taken oftener at the surface, but present sometimes in the bottom and vertical nets. A winter form in the outer bay and a spring form in the inner bay; present also in the ocean outside the bay.

Remarks.—Sars's statement that the most southern place where this species has been observed was the northern coast of France, latitude 48° N., must now be extended to 37° N. Fish found the young

of this species so abundant in January and February at Woods Hole that they far outnumbered the adults, showing that they breed freely there in winter. This species ranks next to *Calanus finmarchicus* in abundance in the Gulf of Maine. It is very much less abundant in Chesapeake Bay, and its percentage mark only rarely gets above 5, and is frequently less than 1. This is what would naturally be expected of a northern form when found so far south. In a plankton series collected continuously across the North Atlantic by Herdman, this species was very common around both shores and was also taken in mid-ocean.

PSEUDODIAPTOMUS CORONATUS Williams

PLATE 2

Pseudodiaptomus coronatus WILLIAMS, Amer. Nat., vol. 40, p. 641, figs. 1–7, 1906.—SHARPE, Proc. U. S. Nat. Mus., vol. 38, p. 412, fig. 4, 1911.

General characters.—Abdomen of male with four segments, of female with three segments; genital segment of female swollen, asymmetrical, and covered with irregular patches of spines. Fifth legs of female with four segments and a stout terminal spine; fifth legs of male as shown in Plate 2, J.

Specific characters of female.—Body slender, anterior portion elliptical, two and a half times as long as wide; head separated from first thoracic segment and evenly rounded anteriorly. Posterior body quite asymmetrical, the left side more fully developed than the right. Genital segment much swollen, with numerous irregular patches of spines and bristles and a pair of long pointed flaps extending behind the genital orifice. Abdomen of three segments, the two basal ones irregular, the terminal one more symmetrical. Left caudal ramus considerably longer than the right and curved outwards, six and a half times as long as wide; right ramus straight and only five and a half times as long as wide.

The plumose setae at the tips of the rami are each jointed near the center and swollen in front of and behind the joint. The same is true of the setae of the swimming legs, as was shown by Williams, but neither he nor Sharpe mentioned the jointing in the caudal setae.

Every female with egg sacks carried a large left sack, containing about 25 eggs, and a minute right sack containing only two eggs. But Sharpe found one or two females at Woods Hole with egg sacks about equal in size, and a single female that carried one large sack.

First antennae 20 to 22 jointed, the jointing so indistinct as to be practically invisible in places; when reflexed the first antennae do not quite reach the posterior margin of the front body. Second antennae with an outer ramus much longer than the inner one and 3-segmented, the basal segment much shorter than either of the other two, the terminal segment ending in three very long plumose setae.

The inner ramus also ends in three long setae, with a tuft of five others on the inner margin near the tip of the terminal joint.

Chewing blade of the mandible broad and stout, with very irregular margins; teeth small, blunt, and all about the same size except the one at the inner corner, which is long, slender, sharply pointed, and pectinate. Outer ramus of palp 4-segmented, inner ramus 2-segmented, its terminal joint turned at right angles and ending in eight setae, all about the same size and length. First maxillae broadly laminate, with flattened and laminate setae; second maxillae 5-segmented, the setae of the four basal segments mounted on long papillae. Maxillipeds with stout basal joints and a 4-segmented ramus. First four pairs of swimming legs with 3-jointed rami; spines of the exopods with serrated margins; fifth legs uniramose, 4-segmented, each leg tipped with a pectinated spine much longer than the terminal joint.

Specific characters of male.—Like the female but with the posterior body symmetrical; abdomen with four segments when fully matured, in other respects like the young male figured in Plate 2; caudal rami three to three and a half times as long as wide and without marginal hairs. Right fifth leg uniramose, 4-segmented, with a terminal claw much like that in the female; left leg biramose, basipod and exopod 2-segmented, endopod with a single bladelike segment, toothed along its curved outer margin near the tip and at the center. First segment of basipod with fingerlike processes on its inner margin, second joint with coarse hairs on its inner margin; exopod tipped with three or four small spines.

Measurements.—Length: Female, 1.5 mm.; male, 1.2 mm.

Occurrence.—Taken at every station in the bay except J, L, and U; never in any abundance but often with a percentage of less than 1. Definitely a winter form but sometimes present at other seasons; usually taken at or near the bottom in the bay but found only at the surface in the outside ocean.

Distribution.—Nova Scotia (Willey); Narragansett Bay (Williams); Sheepshead Bay, N. Y. (Sharpe); Woods Hole (Sharpe, Fish).

Remarks.—Williams and Sharpe obtained their specimens in summer, except those from Sheepshead Bay, which were taken in September. Fish said it was not a true summer species at Woods Hole, but reached its maximum in fall, when it outnumbered all other copepods. In Chesapeake Bay the maximum seems to be reached still later in fall or early in winter, but even then the percentage rarely gets above 5, all such instances being near the inner end of the bay. The second antennae and mouth parts, with minor details of the rest of the body, are figured in Plate 2 to supplement the account here given.

RHINCALANUS NASUTUS Giesbrecht

Rhincalanus nasutus GIESBRECHT, Fauna und Flora des Golfes von Neapel, vol. 19, p. 154, pl. 3, fig. 6; pl. 9, figs. 6, 14; pl. 12, figs. 9–12, 14, 16, 17; pl. 35, figs. 46, 47, 49, 1892.—G. O. SARS, Crustacea of Norway, vol. 4, p. 15, pls. 6, 7, 1901.

Occurrence.—A few females were taken in the bottom net at the 100-fathom line outside the bay.

Remarks.—This is a distinctive pelagic copepod and is not likely to be found within the bay. Farran[7] said of this species: "As far as concerns its distribution in the greater part of the Atlantic, it may be regarded as an inhabitant of the Atlantic current, its distribution to the north and east depending on the varying strength of that stream."

TEMORA DISCAUDATA Giesbrecht

Temora discaudata GIESBRECHT, Atti Accademei Lincei, Rome, ser. 4, vol. 5, p. 814, 1889; Fauna und Flora des Golfes von Neapel, vol. 19, p. 328, pl. 17. figs. 3, 20, 23; pl. 38, figs. 24, 25, 28; 1892.

Occurrence.—A few specimens were obtained in the surface net at Station C, October 20, 1920, and in the bottom net at Station F on October 21. At neither place did the catch include a sufficient number to be worthy of a percentage mark.

Remarks.—This species has not been hitherto reported from the North Atlantic, but is easily recognized by the sharp projections at the posterior corners of the fourth thoracic segment, the asymmetrical furca of the female, and the peculiar fifth legs of the male. It did not occur in sufficient abundance to become of any economic importance as a constituent of the plankton.

TEMORA LONGICORNIS (Müller)

Cyclops longicornis O. F. MÜLLER, Entomostraca seu insecta testacea, p. 115, 1792.

Temora longicornis G. O. SARS, Crustacea of Norway, vol. 4, p. 97, pls. 65, 66. 1902.

Occurrence.—Taken in small numbers in bottom and vertical nets at Stations E, F, and G at the mouth of the bay, and in the vertical net at Station Y. It was also present at the surface in the outside ocean.

Remarks.—Williams found this species all through the year in Narragansett Bay, but Fish listed it as one of the three typical winter forms at Woods Hole. It apparently occurs only in winter in Chesapeake Bay and even then in small numbers. Its presence at both ends of the bay indicates that it may be found at times anywhere in the bay.

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[7] Bulletin Trimestriel, pt. 1, p. 65, 1910.

TEMORA TURBINATA (Dana)

Calanus turbinatus DANA, Wilkes Expedition, Crustacea, vol. 14, p. 1057, 1853.
Temora turbinata GIESBRECHT, Fauna und Flora des Golfes von Neapel, vol. 19. p. 329, pl. 17, figs. 14, 17, 18, 21; pl. 38, fig. 27; 1892.

Occurrence.—Found only during autumn and winter in the outer bay at stations near the mouth. Taken at the bottom, at the surface, and in the vertical net in consecutive hauls at one station. A single surface haul at Station F, December 4, 1920, yielded 1,000 specimens of this species.

Remarks.—This species has not hitherto been reported from our American shores. It can be distinguished from *longicornis* most readily by the short anal segment and the details of the fifth legs. Although it was not found at all in the inner bay, it was present in the outer bay in numbers sufficiently large to give it considerable economic importance. In all probability it furnishes an important constituent in the food of the shad when they come to the bay in their spring migration.

Suborder HARPACTICOIDA

ALTEUTHA DEPRESSA Baird

Alteutha depressa BAIRD, British Entomostraca, p. 216, pl. 30, figs. 1, 2, 1850.—G. O. SARS, Crustacea of Norway, vol. 5, p. 64, pl. 38, 1904.

Occurrence.—Taken at Station F over a sandy bottom in 16 meters of water, at Station G′ over a bottom of mixed sand, gravel, and mud in 28 meters of water, and also in surface and vertical nets; found only during December and January. Not enough specimens were obtained in any one haul to equal even 1 per cent of the total.

Remarks.—This littoral harpactid was found in such small numbers and was so restricted in its distribution at the very mouth of the bay that it must be regarded as a straggler from the outside ocean.

CANUELLA ELONGATA, new species

PLATE 3, A–H

General characters.—Body of nearly the same width throughout, slightly narrowed posteriorly, with deep grooves between the segments. Abdomen with three segments; caudal rami twice the length of the last segment, inclined at an angle of 45° with the body axis, each tipped with four setae.

Specific characters of female.—Head small and a little wider than the first segment, from which it is distinctly separated. Lateral areas slightly and rather squarely expanded; rostral plate broad and rounded at the tip. First thoracic segment well defined, but much shorter than the others, succeeding segments about the same length and width. Genital segment slightly narrower than the fifth

segment, a little longer than wide, with a transverse dorsal suture nearly at the center. The two basal segments of the abdomen nearly the same length and width, the terminal segment about as wide as the others but much shorter. Caudal rami tapered so that the tips are about half the width of the bases. Of the four terminal setae on each ramus the two outside ones are short, the two between them longer, the inner of these two twice as long as the outer. Both the upper and the under surfaces of these rami are covered with short hairs.

The first antennae are stout, 5-segmented, and armed with coarsely plumose setae. The exopod of the second antennae is as long as the endopod and 7-segmented, and both rami are armed with stout setae. The chewing blade of the mandible is stout and widened considerably at the tip, which is armed with five coarse and rather blunt teeth on the inner side, and a bunch of four or five slender and very sharp ones at the outer corner. Maxillae and maxilliped similar to those in other species of the genus, with minor differences.

First legs shorter than the other pairs; spines on the exopod long, stout, and pectinate; endopod much longer than the exopod but not so wide; spine just inside the base of the endopod nearly as long as the two basal joints of the latter and smooth. Fourth legs slender, the endopod much longer than the exopod, with small and comparatively weak spines at the inner distal corners of the first two joints; no spine on the outer margin of the terminal joint of the exopod and no seta on the inner margin of the second joint. Fifth leg a minute lamina, tipped with four tiny setae. Egg sacs large and elongate-oval in form.

Color (preserved material).—A light brownish yellow.

Measurements.—Total length, including furcal rami, 1.65 mm.; width of head, 0.3 mm.

Occurrence.—Seven females, two of which carried egg sacs, were obtained in the bottom net at Station W on June 3, 1921, drawn from a depth of 13 meters over a muddy bottom. The male is unknown.

Types.—U.S.N.M. No. 58571, holotype; No. 63417, paratypes.

Remarks.—T. Scott established this genus for a species obtained in the Firth of Forth. G. O. Sars found the same species on the Norwegian coast and also a new species in the upper part of Christiania Fiord. The present species differs from these two in the length of the abdomen, in the width and bluntness of the rostral plate, and in the details of the mandibles and the first and fourth swimming legs. Like the other species it was found in shallow water over a muddy bottom. It does not occur in sufficient abundance to render it of any economic importance in the life of the bay.

CLETODES LONGICAUDATUS (Boeck)

Enhydrosoma longicaudata BOECK, Christiania Videnskebeliger Selskabet Forhandlinger, p. 54, 1872.

Cletodes longicaudatus G. O. SARS, Crustacea of Norway, vol. 5, p. 286, pl. 197, 1909.

Occurrence.—About 20 specimens of this copepod were taken in a bottom net at Station R on December 8, 1920, drawn from a depth of 47.5 meters over a bottom of mixed mud and sand. This was the only appearance of the species during the entire survey.

Remarks.—The copepod first described by Brady and Robertson in 1875 and afterward by Brady alone in his British Copepoda as *Cletodes longicaudatus* is not identical with the present species, and possibly, as Sars suggests, does not even belong to the same genus. So far as known the species has not before been reported from our American coast.

CLYTEMNESTRA ROSTRATA (Brady)

Goniopsyllus rostratus BRADY, Challenger Copepoda, p. 107, pl. 42, figs. 9–16, 1883.

Clytemnestra rostrata GIESBRECHT, Fauna und Flora des Golfes von Neapel, vol. 19, pp. 566, 572, pl. 45, figs. 19, 20, 22, 25, 26, 31, 33, 1892.

Occurrence.—Obtained only at the surface in the ocean outside the bay, where the depths were 118 and 67 fathoms. The combined catches consisted of only a few specimens, including both sexes.

Remarks.—This copepod nowhere occurs in any abundance; Brady obtained but a single specimen, and Esterly reported one female in summer, but added "occurs also in winter" without specifying the number. Brian and Giesbrecht recorded it as rare in the Mediterranean, and it apparently never becomes numerous enough to possess economic value. It is a pelagic copepod and is not likely to be found within the limits of the bay.

DACTYLOPUSIA BREVICORNIS (Claus)

Dactylopus brevicornis CLAUS, Die Copepodenfauna von Nizza, p. 29, pl. 3, figs. 20–25, 1866.

Dactylopusia brevicornis G. O. SARS, Crustacea of Norway, vol. 5, p. 130, pl. 80, 1905.

Occurrence.—Two specimens of this species were obtained at Station N′ in a surface net on December 7, 1920, and were the only ones found during the survey.

Remarks.—This tiny harpactid is manifestly a rare species in the bay. Two other species of the genus, more cosmopolitan in their distribution, were obtained by Sharpe at Woods Hole, but the present one has not been hitherto reported from our American shores. It is abundant in the Mediterranean, and Brian has given a

detailed description of five copepodid stages in its life history. It is a littoral form and is easily distinguished from the other species of the genus.

DIOSACCUS TENUICORNIS (Claus)

Dactylopus tenuicornis Claus, Die frei lebenden Copepoden, p. 127, pl. 16, figs. 17–23, 1863.

Diosaccus tenuicornis G. O. Sars, Crustacea of Norway, vol. 5, p. 146, pls. 89, 90, 1906.

Occurrence.—A single female was taken in the vertical net at Station F on December 4, 1920, in water 16 meters deep over a muddy bottom. This was the only specimen obtained during the survey.

Remarks.—Sars said that this species was abundant along the whole Norwegian coast in the littoral zone among the algae. It is probable, therefore, that it occurs in Chesapeake Bay in greater abundance than this single capture indicates. It is not likely, however, to become of economic importance in the plankton of the bay.

ECTINOSOMA CURTICORNE Boeck

Ectinosoma curticorne Boeck, Christiania Vidensk. Selskabet Forhandlinger, p. 45, 1872.—G. O. Sars, Crustacea of Norway, vol. 5, p. 36, pl. 20, 1904.

Occurrence.—Well distributed, more particularly in the inner bay, where it was found at a majority of the stations. Taken usually in the bottom net in the outer bay, but often at the surface in the inner bay. A winter species but lasting into spring and sometimes into summer. The largest single haul was in a vertical net at Station Z on March 27, 1921, in 13 meters of water over a muddy bottom, when about 700 specimens were obtained.

Remarks.—This little copepod is found in sufficient numbers in the inner bay to form an important constituent of the plankton. It is evidently a littoral species and lives in brackish water.

ECTINOSOMA NORMANI T. and A. Scott

Ectinosoma normani T. and A. Scott, Trans. Linnaean Soc. London, vol. 6, p. 435, pl. 36, figs. 21, 29, 39; pl. 37, figs. 12, 26, 34, 51; pl. 38, figs. 5, 18, 42, 45; 1897.—G. O. Sars, Crustacea of Norway, vol. 5, p. 35, pl. 19, 1904.

Occurrence.—About 30 specimens of this species, all females, were taken in the bottom net at Station Y, January 27, 1921, from water 20 meters deep over a muddy bottom; this is the only record for the bay.

Remarks.—This species is much less common than *E. curticorne* and probably occurs but rarely in the bay. Like the other species of the genus it is a littoral form and lives in the shallower and less saline water. The bright-red pigment patch on each side of the head between the bases of the first and second antennae forms a

striking character, and the color remains in some of the preserved specimens. This furnishes a quick method of distinguishing the species from others of the genus, and the distinction can afterward be verified by an examination of the fifth legs.

HARPACTICUS CHELIFER (O. F. Müller)

Cyclops chelifer O. F. MÜLLER, Zoologicus Danaae Prodromus, p. 2913, 1776; Entomostraca, p. 114, pl. 13, figs. 1–3, 1785.

Harpacticus chelifer G. O. SARS, Crustacea of Norway, vol. 5, p. 49, pls. 27, 28, 1904.

Occurrence.—Only two females of this species were taken, at Station G in a surface net December 4, 1920.

Remarks.—This is a northern form, littoral in habit, and hence is likely to occur in any numbers in the bay. It can be recognized at once by the enormous chelae on the maxillipeds, which are much larger than those of other species of the genus. Sars recorded it as found in "quite shallow water close to the shore among algae, and not infrequently left in tidal pools together with other littoral species." From the distribution given by various authors this is an extremely cosmopolitan species, appearing in nearly every sea and ocean.

HARPACTICUS GRACILIS Claus

Harpacticus gracilis CLAUS, Die frei lebenden Copepoden, p. 135, pl. 19, fig. 20, 1863.—G. O. SARS, Crustacea of Norway, vol. 5, p. 52, pl. 30, 1904.

Occurrence.—Widely distributed throughout the bay but more abundant in the inner portion. Taken most frequently at the surface and in the winter, but lasting into spring and sometimes into summer. Nowhere found in sufficient numbers to constitute more than 1 or 2 per cent of the total haul, and usually much less than that.

Remarks.—In spite of the wide distribution of this copepod throughout the bay, the small numbers found at each station prevent it from becoming of much importance in the economy of the plankton. It does help, however, by its continued presence through most of the year, and contributes its quota toward the food supply. It is a littoral form and was reported by both Sars and Brian as found in comparatively shallow water among algae. As far as known it has not before been reported from our American coasts.

HARPACTICUS LITTORALIS G. O. Sars

Harpacticus chelifer BRADY, British Copepoda, vol. 2, p. 146, pl. 64, figs. 19–20; pl. 65, figs. 1–15, 1880.

Harpacticus littoralis G. O. SARS, Crustacea of Norway, vol. 5, 363, suppl. pl. 8, 1910.

Occurrence.—About 40 specimens of this species were obtained in a surface net at Station R′ on December 8, 1920, and a few stragglers were also taken at Stations S and T.

Remarks.—Sars said of this copepod: "It is a pronouncedly littoral species, being generally found in very shallow water, especially in flat sandy creeks." R′ and T were two of the shallowest stations in the bay, the water measuring 7 and 9 meters, respectively, but S was considerably deeper. In all three, however, the water was decidedly brackish, especially at the surface, where these specimens were obtained. In general, therefore, the conditions here in Chesapeake Bay correspond favorably with those given by Sars.

MACROSETELLA GRACILIS (Dana)

Setella gracilis DANA, Wilkes Expedition, Crustacea, vol. 14, p. 1198, pl. 84, fig. 3, *a–g*, 1853.—WHEELER, Bull. U. S. Bur. Fisheries, vol. 19, p. 188, fig. 24, 1900.

Occurrence.—Nearly 100 specimens of this species were taken in a surface net over a depth of 67 fathoms in the outside ocean; none were found within the limits of the bay.

Remarks.—This copepod can be recognized at once by its linear body and excessively long caudal setae. It is a true pelagic form and is not likely to be found anywhere in the bay.

MICROSETELLA NORVEGICA (Boeck)

Setella norvegica BOECK, Christiania Videnskebeliger Selskabet Forhandlinger, pl. 11, fig. 1 (9 figs.), 1864.

Microsetella norvegica G. O. SARS, Crustacea of Norway, vol. 5, p. 44, pl. 24, 1904.

Occurrence.—About 100 specimens, including both sexes, were obtained in a vertical net at Station F on December 4, 1920, and 70 more in a surface net at Station E on January 22, 1921.

Remarks.—From the distribution given by various authors this is a very cosmopolitan species. According to Sars it is a true pelagic copepod, always taken near the surface and usually at a considerable distance from shore. Although it did not appear during the August trip to the 100-fathom line, it is probably present there in winter and early in spring, the season at which it was found at the mouth of the bay.

MICROTHALESTRIS LITTORALIS G. O. Sars

Microthalestris littoralis G. O. SARS, Crustacea of Norway, vol. 5, p. 369, suppl. pl. 11, fig. 1 (9 figs.), 1911.

Occurrence.—This species was widely distributed throughout the entire bay, but was nowhere abundant. The largest haul was at Station T in a bottom net on March 29, 1921, from water 9 meters deep over a muddy bottom. Here it constituted 1 per cent of a catch that totaled 25,000, but its numbers were usually so small as to fall below a percentage mark.

Remarks.—Sars called this harpactid "a pronouncedly littoral form, being only found in the uppermost part of the littoral zone, and very often in shallow pools left by the tide." In Chesapeake Bay it was almost wholly confined to winter and early spring. Being a new species established by Sars and afterward found by Steur, Pesta, and Brian in the Mediterranean, it has never before been reported from our American coast. Sars found only the female, but Brian added the male of the species, and the present specimens included also both sexes.

ROBERTSONIA CHESAPEAKENSIS, new species

PLATE 4, A–I

Specific characters of female.—Body fairly stout, almost cylindrical; anterior portion considerably dilated, a little more than half as wide as long, widest in the center. Cephalic segment nearly equaling in length the entire thorax, widest across its posterior margin. Rostrum narrow-triangular, longer than wide and bluntly pointed. Second, third, and fourth thoracic segments smoothly rounded at their posterior corners. Posterior body three-quarters as long and a little more than half as wide as the anterior. Genital segment as long as the entire abdomen, with a transverse suture near the center, which is distinct on the sides and ventral surface but fades out on the dorsal surface. Abdomen of three segments, diminishing in length posteriorly; anal segment with an angular notch between the bases of the caudal rami; the latter wider than long, obtusely truncated and tipped with two long and several shorter setae. Eye small but fairly distinct. Egg case single.

Specific characters of male.—Body regions similar to those of the female, posterior body rather stouter; its segments fringed on their posterior margins with slender spines, especially prominent on the ventral surface. Terminal setae of caudal rami considerably stouter than in the female, the longest one as long as the entire posterior body.

First antennae 7-segmented, rather densely setose, the fourth segment enlarged and armed with two aesthetasks. Second antennae short and stout, the proximal segment a little longer than the distal and armed on its anterior margin with a stout seta. The outer ramus 2-segmented nearly as long as the distal segment and carrying five setae, two lateral, and three terminal. Mandibular palp with a broad, laminate terminal joint armed with a tuft of setae on its rounded tip and a single longer one on the inner margin near the center. Maxilliped of moderate size, the basal joint with two long setae and several smaller ones at the anterior distal corner; terminal joint about as long as the basal and considerably swollen, with four

or five long setae on its anterior margin; claw fully as long as the terminal joint and itself segmented near the base, where it carries a few long setae on its outer margin.

Endopod of first legs much longer than the exopod, with three fingerlike processes on the outer margin of the second segment. Endopod of second legs prehensile, the second segment tipped with two long and slender, spinelike appendages, closely juxtaposed, each ending in a minute claw. On the inner margin of this segment close to the bases of the spines are two setae, longer than the spines. Fifth legs with the terminal segment broadly triangular and armed with five large plumose setae and a much smaller nonplumose one, the third from the inner corner. Inner expansion of the basal segment not quite reaching the tip of the terminal segment and tipped with two plumose setae. A pair of rudimentary sixth legs on the ventral surface of the genital segment just behind the median suture, each consisting of a small knob tipped with three setae.

Color (preserved material).—Light brown.

Measurements.—Length: Female, 0.7 mm.; male, 0.8 mm.

Occurrence.—Several specimens, including but a single female, were taken in a bottom net at Station T on March 29, 1921, from water 9 meters deep over a muddy bottom. The species was not found elsewhere in the bay.

Types.—U.S.N.M. No. 58561, male, holotype; No. 63418, 2 males, 1 female, paratypes.

Remarks.—The single female was kept intact, and the description of the appendages is based upon those of the male, which are contrasted with the male of *tenuis*, the genus type, described by Sars.[8] The chief points of difference are found in the general body form, especially the proportions of the various parts, and in the details of the second antennae, mandible, and second legs.

TACHIDIUS LITTORALIS Poppe

Tachidius littoralis Poppe, Abh. Naturw. Vereine, vol. 7, p. 149, pl. 6, 1881.

Occurrence.—A few females were taken at the surface at Station L′ on October 19, 1920, in water 8 meters deep. A single female was captured in the bottom net at Station N′ on January 25, 1921, in water 11 meters deep.

Remarks.—Poppe's specimens came from the mouth of the Ems River in northwestern Germany. Brady classed it as a brackish-water species found in estuaries and salt marshes. Such localities agree well with the two shallow water stations here in Chesapeake Bay, mentioned above. As far as known the species has not before been reported from American shores.

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[8] Crustacea of Norway, vol. 5, p. 334, pl. 222, 1909.

TISBE FURCATA (Baird)

Canthocamptus furcatus BAIRD, British Entomostraca, p. 210, pl. 25, figs. 1–2; pl. 30, figs. 4–6; 1850.

Idyaea furcata G. O. SARS, Crustacea of Norway, vol. 5, p. 88; pls. 51, 52, fig. 1, 1905; p. 367, 1910.

Occurrence.—Taken at Station G′ in a vertical net on December 4, 1920, and at the surface on May 30, 1921, the latter haul yielding more than 200 specimens. One hundred and fifty specimens were also obtained in a bottom net on the 100-fathom line in the outside ocean.

Remarks.—The genus name of *Idya* being preoccupied, Lilljeborg's name of *Tisbe* must be substituted for it, not *Idyaea*. Sars said: "This is perhaps the commonest and most widely distributed of all our Harpacticoida." It is a littoral form and northern in its habitat, and possibly Chesapeake Bay is near the southern limit of its range.

Suborder CYCLOPOIDA

BOMOLOCHUS EMINENS Wilson

Bomolochus eminens WILSON, Proc. U. S. Nat. Mus., vol. 39, p. 368, pl. 53, figs. 148–154, text fig. 6, 1911.

Occurrence.—Half a dozen specimens, including both sexes, were obtained at Station P in a surface net on August 24 and in a bottom net on October 19, 1920. Development stages, probably of the same species, were also taken at this station.

Remarks.—This species was established to include certain specimens taken from the gill cavity of the false Spanish sardine, *Clupanodon pseudohispanicus*, at the Tortuga Islands. This fish is abundant about Cuba and in the Gulf of Mexico and goes northward along the Atlantic coast as far as Woods Hole. Either this or some closely allied fish probably serves as host to the *Bomolochus* parasite in Chesapeake Bay.

CORYCELLA[9] CARINATA (Giesbrecht)

Corycaeus carinatus GIESBRECHT, Fauna und Flora des Golfes von Neapel, vol. 13, p. 675, pl. 51, figs. 20, 26, 1892.

Occurrence.—About 40 specimens, all females, were obtained at the surface on the 100-fathom line on August 21, 1921, and a few were taken in a vertical net at Station G in the mouth of the bay on December 4, 1920.

Remarks.—This is evidently a pelagic form and does not get far into the bay. From the dates given by other authors, this copepod is probably found throughout the year in the open ocean.

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[9] The name *Corycella* Farran, 1911, was used by Leger for a genus of Protozoa in 1893. Blake has proposed in manuscript the name *Farranula* for this genus, but as it has not yet been published *Corycella* is retained here.

CORYCAEUS ELONGATUS Claus

Corycaeus elongatus CLAUS, Die frei lebenden Copepoden, p. 157, pl. 24, figs. 3, 4, 1863.—GIESBRECHT, Fauna und Flora des Golfes von Neapel, vol. 19, p. 674, pl. 15, figs. 6, 7, 1892.

Occurrence.—A few specimens, including both sexes, were taken in a bottom net at Station C on December 20, 1920, and a few females were captured in a surface net in the outside ocean on August 21, 1921.

Remarks.—This copepod advanced a little farther into the bay during winter than *Corycella carinata.* According to the authors the present species does not seem to be abundant anywhere, but is always found in small numbers. This fact and its small size make it of no economic importance in the plankton of the bay.

CORYCAEUS LUBBOCKII Giesbrecht

Corycaeus lubbockii GIESBRECHT, Fauna und Flora des Golfes von Neapel, vol. 19, p. 674, pl. 51, figs. 57, 58, 1892.

CORYCAEUS ROBUSTUS Giesbrecht

Corycaeus robustus GIESBRECHT, Fauna und Flora des Golfes von Neapel, vol. 19, p. 673, pl. 51, fig. 38, 1892.

CORYCAEUS ROSTRATUS Claus

Corycaeus rostratus CLAUS, Die frei lebenden Copepoden, p. 157, pl. 28, fig. 5, 1863.—GIESBRECHT, Fauna und Flora des Golfes von Neapel, vol. 19, p. 674, pl. 51, fig. 16, 1892.

CORYCAEUS SPECIOSUS Dana

Corycaeus speciosus DANA, Wilkes Expedition, Crustacea, vol. 14, pt. 2, p. 1220, pl. 86, fig. 1, 1, *a–d*, 1853.—GIESBRECHT, Fauna und Flora des Golfes von Neapel, vol. 19, p. 673, pl. 51, fig. 40, 1892.

Occurrence.—These four species of *Corycaeus* were found in small numbers at the surface on the 100-fathom line, and were not taken within the limits of the bay.

Remarks.—From the locality where they were found it will be seen that these four species are pelagic copepods not likely to be taken within the limits of the bay. Moreover they are not found anywhere in abundance but always in very small numbers. Together with their small size, this prevents them from becoming of economic importance.

CORYCAEUS VENUSTUS Dana

Corycaeus Venustus DANA, Wilkes Expedition, Crustacea, vol. 14, p. 1222, pl 86, fig. 4*a*, 1853.—GIESBRECHT, Fauna und Flora des Golfes von Neapel, vol. 19, p. 674, pl. 51, figs. 32–34, 47, 1892.

Occurrence.—Found in small numbers at Stations B, C, E, and F in surface and vertical nets during autumn and winter; also in surface and bottom nets on the 100-fathom line in the outside ocean.

Remarks.—This was the most widely distributed species of *Corycaeus* in the bay, but like all the others it occurred only in very small numbers. It is quite different from the other species in dorsal view and may be recognized without much difficulty.

CRYPTOPONTIUS GRACILIS, new species

PLATE 4, J–S

Specific characters of female.—Anterior body broadly expanded but not strongly depressed, with the epimeral lappets close together and curved backward. Cephalothorax as wide as long and about a fifth longer than the remainder of the body, broadly rounded in front with no dorsal crista; rostral projection minute. Lappets on the second and third thoracic segments broad and pointed, those on the third segment not reaching the center of the genital segment. Lappets of the fourth segment very small and conical in form, almost wholly concealed in dorsal view. Fifth segment very short and narrow and without lappets. Anterior half of genital segment dilated laterally to nearly twice the width of the posterior half. Abdomen with three segments, decreasing in width, but increasing in length posteriorly. Caudal rami as wide as long and rounded at the tip, each carrying five setae, of which the second from the inside is the longest and the second from the outside is the shortest.

Anterior antennae with nine segments, of which the second is short and the third and ninth quite long. According to Giesbrecht's interpretation the long third joint represents segments 3 to 8 fused, the fourth joint segments 9 to 11 fused, the fifth joint the twelfth segment, the sixth, seventh, and eighth joints three segments each, and the ninth joint segments 22 to 25 fused. On this basis the large aesthetask, which is two-thirds as long as the entire antenna, is attached to the twenty-third segment.

The posterior antennae are 4-segmented, the second and fourth joints about equal and much longer than the first and third, the middle terminal seta stout and rigid. The rudimentary exopod is rather large and is tipped with a single seta. The mouth tube is slender and extends nearly to the posterior margin of the cephalothorax; its basal portion is a little more than six times as wide as the terminal. The outer lobe of the maxilla is two-thirds as long as the inner, with a single stout apical seta, while the inner lobe ends in a minute seta. The terminal segment of the second maxilla is but little longer than the basal and enlarged at its tip, with a short and stout terminal claw. The terminal claw of the maxilliped is stout and is not so long as the second and third joints combined.

Specific characters of male.—Cephalothorax a fifth longer than wide and also a fifth longer than the rest of the body. The first antennae have ten segments, with aesthetasks of half the length of

the entire antenna on the dorsal surface of segments two to eight. The entire genital segment is dilated to twice the width of the abdomen; the latter has four segments, of which the basal and terminal are twice the length of the other two.

Color (preserved material).—Uniform yellowish white.

Measurements.—Length: Female, 1 mm.; male, 0.85 mm.

Occurrence.—Six specimens, including both sexes, were taken in a bottom net at Station A on December 5, 1920, in water 46 meters deep over a bottom of black mud. This station is well inside the mouth of the bay, and the species may occur elsewhere.

Types.—U.S.N.M. No. 58562, male, holotype; No. 63419, 1 male, 4 females, paratypes.

Remarks.—This species is closely related to *brevifurcatus*, the type of the genus, but differs in the greatly increased width and decreased length of the cephalothorax of the female, and in the details of the various appendages, especially the mouth tube and the first maxillae. In Sars's figure of the female of *brevifurcatus* the cephalothorax is twice as long as wide and also twice as long as the remainder of the body. In Giesbrecht's figure of the male the cephalothorax is only one-fifth longer than wide, but is nearly twice as long as the remainder of the body. These are very different proportions from those here given. In the female Sars makes the mouth tube ten times as long as its basal width, with the terminal portion exceedingly slender and tapering regularly to the tip. Here the length is only five times its basal width, and the terminal portion is stout and somewhat enlarged at the tip.

HEMICYCLOPS AMERICANUS, new species

PLATE 5, A–H

Specific characters of female.—Body cyclopoid and fairly stout, with the anterior division sharply separated from the posterior, strongly depressed and obovate in outline. Cephalic segment considerably wider than its length on the midline, and longer than the four succeeding segments combined, with a small triangular rostral process, invisible dorsally. Epimeral plates of the second, third, and fourth segments close together and rounded at their posterior corners, the fourth segment a little more than half the width of the cephalon. Fifth segment abruptly contracted to half the width of the fourth, swollen through the bases of the fifth legs, and strongly narrowed anteriorly. Genital segment a little wider than fifth segment anteriorly but tapered posteriorly, with a median transverse suture visible at the sides but fading out on the dorsal surface. Abdomen of three segments slightly tapered, the basal segment the longest, the second

segment the shortest. Caudal rami twice as long as wide, rounded at their tips and almost parallel. Egg cases elongate-ovate in form, reaching the anterior margin of the last abdominal segment.

First antennae reaching but little beyond the center of the cephalothorax, abruptly bent at their base and considerably tapered, the second and fourth segments the longest. Second antennae projecting beyond the margin of the carapace, penultimate joint wider than long, much shorter than the antepenultimate and terminal joints; distal corner strongly produced and armed with a tuft of stout setae; terminal joint tipped with six strong setae, four of which are geniculate, and a few short bristles.

First maxillae tipped with two stout spines and two setae on the inner margin inside the spines; palp tipped with four setae, with a well-defined lobe on the inner margin, also bearing four setae. Second maxillae with two coarse setae and a tiny one between them near the tip of the proximal joint on the inner margin; distal joint tipped with two stout clawlike spines and two setae about as long as the spines. Maxillipeds with the middle joint slightly swollen on the inner margin and armed with two plumose setae; terminal joint tipped with two plumose setae, but without any curved spines.

Swimming legs with the endopods longer than the exopods, the spines on both rami slender, minutely pectinate and armed just below the tip with a threadlike cilia. Fifth legs with a widened proximal joint carrying a stout seta on the anterior distal corner; distal joint laminate, densely ciliate on the lateral margins, with a few minute spines on the posterior margin near the tip, an apical spine accompanied by a bristle, and three spines on the anterior margin, all the spines pectinate.

Color (preserved material).—Clear yellowish white.

Measurements.—Length of adult female, 1.65 mm.; width of cephalothorax, 0.65 mm.

Occurrence.—Two females were obtained in a bottom net at Station R′ in water 7 meters deep over a bottom of muddy sand on June 2, 1921; four females in a bottom net at Station W on March 25, 1921, in 13 meters of water over a muddy bottom; and two females at the latter station in a bottom net on June 3, 1921. The first two are made the types.

Types.—U. S. N. M. No. 58563, holotype; No. 63420, paratype.

Remarks.—From the record just given it is evident that this copepod is probably a bottom species, found in the brackish water of the inner bay during spring and summer. The type species of the genus, *purpureus*, was found by Sars in the Christiana Fiord on the Norwegian coast and was also recorded by T. Scott from the coast of Scotland.

METACYCLOPS GRACILIS (Lilljeborg)

Cyclops gracilis LILLJEBORG, De Crustaceis ex ordinibus tribus in Scania occurrentibus, Appendix, p. 208, 1853.

Mesocyclops gracilis G. O. SARS, Crustacea of Norway, vol. 6, p. 63; pl. 39, 1914.

Metacyclops gracilis KIEFER, Das Tierreich, Lief. 53, p. 72, 1929.

Occurrence.—Fourteen specimens of this species were taken in a surface net at Station Z on October 17, 1920, in water 13 meters deep over a muddy bottom.

Remarks.—This is a fresh-water species that has been found in central Europe and on the Scandinavian peninsula, but has not been heretofore reported from American waters. The salinity at the surface where the specimens were obtained was 10.4, which is not high enough to offer any serious obstacle to their presence. They might easily have drifted out of the Patapsco River, the mouth of which is just above Station Z. But it is also evident that their presence at the station was accidental, and that they are not likely to be found in any abundance or to be widely distributed in the bay.

OITHONA BREVICORNIS Giesbrecht

PLATE 3, I; PLATE 5, I–N

Oithona brevicornis GIESBRECHT, Atti Accademei Lincei, Rome, ser. 4, vol. 7, p. 475, 1891; Fauna und Flora des Golfes von Neapel, vol. 19, 538, pl. 34, figs. 6, 7, 1892.—FARRAN, Proc. Zool. Soc. London, 1913, p. 191.

Farran gave the following specific characters in the reference given above: "Rostrum present, ventrally directed, short, curved, not visible in dorsal view; exopod of first foot with 1.1.3 outer edge spines; exopod of fourth foot with 1.1.2 outer edge spines; length 0.7 mm." Giesbrecht in the second reference above, under the diagnoses of the species of *Oithona* on page 754, enumerated the following characters for the present species: "Forehead ending in a pointed rostrum, directed ventrally and not visible in dorsal view. First antennae scarcely reaching the posterior margin of the front body or falling distinctly short of it. Furca longer than the anal segment. Length 0.7 mm." The present specimens agree with these diagnoses except that the caudal rami are sometimes apparently shorter than the anal segment. In Giesbrecht's figure of the female in dorsal view (pl. 34, fig. 6) he put in a short anal segment next to the caudal rami similar to the one seen in the male. This was visible in about half the Chesapeake Bay specimens, but in the other half it was indistinguishably fused with the segment in front of it, and the two together were longer than the caudal rami. Giesbrecht also wrote that the male was unknown, and Farran accepted his statement. The only description of the female is the one given by Giesbrecht, which is extremely brief and tells us nothing about the appendages. Accordingly a

detailed description is here given of both sexes, with figures of the appendages to supply the omitted details.

Specific characters of female.—Body of the usual slender form but relatively stouter than in any species except *robusta* and *hebes*, the width of the anterior portion being nearly half its length. Rostrum considerably shorter than that of *similis* and *robusta*, pointed and curved over ventrally so as to be wholly invisible in dorsal view. Head more or less completely fused with the first thoracic segment, the dividing suture often practically invisible. Head itself half the length of the anterior body; first thoracic segment as wide as the head, the second, third, and fourth segments tapering regularly backward, the fourth one a trifle more than half the width of the first. Fifth segment abruptly contracted into a narrow neck anteriorly, swollen through the bases of the fifth legs to twice the width of the neck, and contracted again posteriorly. Genital segment swollen anteriorly and tapered posteriorly, as long as the entire abdomen, with the transverse suture just in front of the center. Abdomen of three segments, the terminal or anal one the shortest and often indistinguishably fused with the one in front of it. Caudal rami longer than this anal segment, more than twice as long as wide, each tipped with four setae. The second seta from the outside is the longest and is curved inward across the base of the one next to it, which is second in length.

First antennae slender and, when reflexed, reaching the posterior margin of the second thoracic segment; composed of about 11 segments, but the grooving of the basal portion is so faintly defined as to be very uncertain. Second antennae 2-jointed, the terminal joint a little shorter than the basal and tipped with a tuft of six plumose setae, with three others on the outer margin nearer the proximal end. First maxillae with the masticatory lobe large and tipped with two very stout setalike appendages, and on the outer margin a small jointed knob carrying spines; proximal lobe recurved, ending in three long setae, with two other shorter ones on the outer margin. Second maxillae 5-jointed, basal joint with three setae and a knob bearing three other setae; second with two setae; third joint with two large setae and a third much smaller one; fourth joint with a single seta on each distal corner; fifth joint tipped with two setae. The large setae are branched rather than plumose, the branches scattered and much too large for plumes. Maxillipeds 4-jointed, basal joint with one large and two small setae; second joint with two large setae; third joint with two of moderate size; last joint with one large and a smaller one. Swimming legs like those of other species of *Oithona*, the exopod of the first pair with 1.1.3 outer-edge spines, and the exopod of the fourth pair with 1.1.2 outer-edge spines.

Specific characters of male.—Body proportionally wider than in the female; length of anterior body to width as 16 to 9 (as 9 to 4 in the female); greatest width at posterior margin of cephalothorax, while in the female it is a short distance in front of that margin. Second segment as wide as the cephalothorax, third segment narrowed a little, fourth segment abruptly contracted to three-fifths of the width of the third segment; fifth segment nearly circular in outline, fifth legs longer than in the female. Genital segment ovate, armed on the dorsal surface at each posterior corner with a long seta. Abdomen of four segments, all the same width; caudal rami considerably longer than the anal segment and three times as long as wide.

First antennae apparently 14-jointed, but with the jointing of the basal portion very indistinct; terminal portion made up of two joints of about the same length. The basal portion of each antenna is bent near its center, and the joint at the flexure is armed at its distal posterior corner with a small spine inside of which is a rather long seta. The second antennae and mouth parts are like those of the female.

Measurements.—Female: Total length, 0.6 mm.; length of anterior body, 0.33 mm.; greatest width, 0.15 mm.; length of posterior body, 0.27 mm. *Male:* Total length, 0.55 mm.; length of anterior body, 0.32 mm.; greatest width, 0.18 mm.; length of posterior body, 0.23 mm.

Occurrence.—Taken at every station in the bay except U, abundant everywhere and sometimes constituting 50 per cent or more of the total catch. More abundant in the inner bay than in the outer, although the two largest single hauls of the species were both made in the outer bay.

Distribution.—Western Pacific near Hong Kong (Giesbrecht); Mediterranean (Pesta, Giesbrecht); Atlantic Ocean, latitude 6° S. (Cleve); Woods Hole (Fish).

Remarks.—The peculiar crossing of the long setae on the caudal rami of the female is a notable characteristic of this species. It is one of the smallest copepods in the bay, but also next to the two Acartias it is the most widely distributed. Hence its regular occurrence and comparative abundance more than offset its diminutive size and make it of great economic importance in the plankton. It was not found by Esterly on the California coast, but its place was taken by *Oithona nana*, another of Giesbrecht's species. A comparison of specimens taken at Woods Hole in the summer of 1923 with these from Chesapeake Bay shows that the two are the same species. Fish has recorded it as a summer form, while in Chesapeake Bay it was found throughout the entire bay during both summer and

winter. It is also found in the outer bay during autumn and probably during spring and in the inner bay during spring. Cleve, in discussing the geographical distribution of Atlantic Copepoda and their physical conditions,[10] gave 20.29 as the mean salinity of the water in which this species was found. In the records here given the average salinity is much less than that, and at several stations was less than 10. This species, therefore, can accommodate itself to marked changes in salinity with almost as much ease as the two species of *Acartia* and *Harpacticus gracilis*.

OITHONA PLUMIFERA Baird

Oithona plumifera BAIRD, Newman's Zool., vol. 1, p. 59, 1843.—GIESBRECHT, Fauna und Flora des Golfes von Neapel, vol. 19, p. 754; pls. 4, 34, 44, 1892.

Occurrence.—This copepod was not found within the limits of the bay, but many specimens were obtained in the bottom net from depths of 20 and 118 fathoms in the outside ocean.

Remarks.—This is a pelagic form and not likely to be found within the limits of the bay. It has never been found anywhere in sufficient abundance to become of more than scientific interest.

OITHONA SIMILIS Claus

Oithona similis CLAUS, Die Copepodenfauna von Nizza, p. 14, 1866.—G. O. SARS, Crustacea of Norway, vol. 6, p. 6 (1918, p. 207), pl. 3, 1913.

Occurrence.—Found at every station in the bay except D, H, M, and U; found much more abundant in the inner bay, but not so well distributed nor in such large numbers as *brevicornis;* decidedly a winter form but present also at other seasons.

Remarks.—Fish lists this copepod as a summer form at Woods Hole, and Wheeler obtained his specimens in July. Chesapeake Bay is much farther south, and while this species was found sometimes in summer in the outer bay, it was taken almost exclusively during autumn and winter in the inner bay. Like *brevicornis*, it was present in sufficient numbers to offset its diminutive size and formed an important addition to the plankton.

OITHONA SPINIROSTRIS Claus

Oithona spinirostris CLAUS, Die frei lebenden Copepoden, p. 105, pl. 11, figs. 4–9, 1863.—G. O. SARS, Crustacea of Norway, vol. 6, p. 6, pls. 1, 2, 1913.

Occurrence.—A few specimens were taken in a surface net at Station G on December 4, 1920. About 40 specimens were also obtained in a bottom net at a depth of 20 fathoms in the outside ocean during the trip to the 100-fathom line on August 21, 1920.

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[10] Ofversigt af Kongl. Vetenskaps-Akademiens Förhandlingar, p. 139, 1900.

Remarks.—This species has been generally confused with *plumifera*, but it lacks the plumes, which are the essential characteristic of that species, and is considerably larger. Like *plumifera* it is a pelagic form, widely distributed over the northern Atlantic, but not likely to penetrate very far into the bay. Sars said of it: "To judge from the structure of the oral parts, the animal must be of a very rapacious nature, probably feeding upon other small pelagic animals." [11]

ONCAEA MINUTA Giesbrecht

Oncaea minuta GIESBRECHT, Fauna und Flora des Golfes von Neapel, vol. 19, p. 603, pl. 47, figs. 3, 6, 26, 46, 59, 1892.—G. O. SARS, Crustacea of Norway, vol. 6, p. 217, pl. 118, fig. 2, 1918.

Occurrence.—About 25 specimens were obtained in a surface net at Station C on August 22, 1920. A few females were also taken at the surface at Station E on October 21, in a bottom net at Station F on August 22, and in a bottom net at Station L on August 25.

Remarks.—This little cyclopid was taken only late in summer and in autumn, and in very small numbers, except at Station C. It has not been reported as abundant anywhere and hence does not become of real importance in the plankton.

ONCAEA VENUSTA Philippi

Oncaea venusta PHILIPPI, Arch. Naturg., vol. 9, p. 111, fig. 3, 1843.—GIESBRECHT, Fauna und Flora des Golfes von Neapel, vol. 19, p. 602, pl. 3, fig. 7; pl. 47, figs. 2, 5, 13, 19, 39, 44, 48, 1892.

Occurrence.—One hundred specimens were obtained at the surface on the 100-fathom line in the outside ocean and 150 in the bottom net. Six hundred were obtained at the surface in water 67 fathoms deep, and 15 in the surface and bottom nets where the depth was 10 fathoms. A single female was found in the mouth of the bay.

Remarks.—This is apparently a pelagic form and widely distributed in all the oceans, to judge from the localities given by various authors. Hence it is not likely to be found inside of the very mouth of the bay.

SAPPHIRINA GEMMA Dana

Sapphirina gemma DANA, Wilkes Expedition, Crustacea, vol. 14, p. 1252, pl. 88, fig. 1, *a–f*; fig. 2, *a–g*; 1853.—GIESBRECHT, Fauna und Flora des Golfes von Neapel, vol. 19, p. 640, pl. 3, fig. 4; pl. 52, figs. 3, 4, 62, 64; pl. 53, figs. 19, 31, 32, 61; pl. 54, figs. 10, 12, 46; 1892.

Occurrence.—A few specimens, including both sexes, were obtained in the bottom net drawn from depths of 40 and 118 fathoms during the trip to the 100-fathom line in the outside ocean.

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[11] Crustacea of Norway, vol. 6, p. 7, 1913.

Remarks.—Though captured swimming freely this copepod lives commensally within some species of *Salpa*. According to Giesbrecht it uses *S. democratica* as a host, but Wheeler's specimens were taken in company with *S. cordiformis*.

SAPPHIRINA SINUICAUDA Brady

Sapphirina sinuicauda BRADY, Challenger Expedition, Copepoda, vol. 8, p. 129, pl. 49, figs. 7–10, 1883.—GIESBRECHT, Fauna und Flora des Golfes von Neapel, vol. 19, p. 648, pl. 52, figs. 31, 33, 34; pl. 53, figs. 42, 50; pl. 54, figs. 26, 36, 70, 1892.

Occurrence.—About 40 specimens of this species were taken in a bottom net at the 100-fathom line in the outside ocean; none were found within the limits of the bay.

Remarks.—Like *S. gemma*, this is also a pelagic form and not likely to be found within the limits of the bay. Thus far all the specimens have been captured while swimming freely, but like other species of the genus it is probable that the present one lives commensally within some species of *Salpa*.

Suborder CALIGOIDA

CALIGUS SCHISTONYX Wilson

Caligus schistonyx WILSON, Proc. U. S. Nat. Mus., vol. 28, p. 564, pl. 6, figs. 65–78, 1905.

Occurrence.—Several specimens were obtained in the surface net at Station G in the mouth of the bay on October 21, and in the vertical net on December 4, 1920. Others were captured in both surface and bottom nets at Station C on October 20, 1920. All the specimens taken were swimming freely in the tow.

Remarks.—Of the 15 lots of this species already in the collection of the United States National Museum, 9 were obtained from the tow. This species is very often captured when swimming freely, probably because it is an external parasite on the common menhaden (*Brevoortia tyrannus*). These fishes serve as the prey or food of other fishes, and while being caught and eaten some of their external parasites would naturally be set free in the water.

SPECIMENS DEPOSITED IN THE UNITED STATES NATIONAL MUSEUM AND INDEX OF SPECIES

Out of the large number of specimens here recorded, those listed in Table 4 have been selected to serve as types of the new species and as samples of the identification of the other species. Considerable care was exercised in the selection of these samples, in order that they might exhibit the average characteristics of the species.

TABLE 4.—*Specimens of copepods reported upon in this paper deposited in the United States National Museum, and index of species*

SPECIES	U. S. N. M. No.	STATION	PAGE
Acartia clausii	58472	J	19
	58482	Y	
	58504	C	
	58514	C	
	58549	Z	
Acartia longiremis	58441	E	20
	58458	F	
	58506	[1] 100-f. l.	
	58512	C	
	58514	C	
Alteutha depressa	58528	F	33
Amallophora brevicornis	58557	100-f. l.	20
Anomalocera patersoni	58558	do	21
Bomolochus eminens	58464	P	41
	58470	do	
Calanus finmarchicus	58455	E	21
	58477	G	
	58502	100-f. l.	
	58509	do	
Calanus helgolandicus			21
Caligus schistonyx	58446	G	51
Candacia armata	58496	100-f. l.	22
	58503	40-f. l.	
Canuella elongata, new species	[2] 58571	W	33
	63417		
Centropages bradyi	58543	100-f. l.	22
Centropages hamatus	58445	E	22
	58488	G	
	58521	100-f. l.	
Centropages typicus	58442	E	23
	58483	E	
	58484	G	
	58516	100-f. l.	
Cletodes longicaudatus	58454	R	35
Clytemnestra rostrata	58529	100-f. l.	35
Corycaeus elongatus	58453	C	42
	58497	do	
Corycaeus lubbockii	58530	100-f. l.	42
Corycaeus robustus	58534	do	42
Corycaeus rostratus	58515	do	42
Corycaeus speciosus	58513	do	42
Corycaeus venustus	58449	E	42
	58520	100-f. l.	
	58559	B	
Corycella carinata	58536	do	41
	58542	G	

[1] 100-fathom line. [2] Type specimen.

TABLE 4.—*Specimens of copepods reported upon in this paper deposited in the United States National Museum, and index of species*—Continued

SPECIES	U. S. N. M. No.	STATION	PAGE
Cryptopontius gracilis, new species	[2] 58562 63419	A	43
Dactylopusia brevicornis			35
Diosaccus tenuicornis	58468	F	36
Ectinosoma curticorne	58469 58556	Z O	36
Ectinosoma normani	58474	Y	36
Euchaeta norvegica	58495	100-f. l.	23
Eurytemora americana	58487	V	24
Eurytemora hirundoides	58524 58550	M Z	24
Harpacticus chelifer			37
Harpacticus gracilis	58493	V	37
Harpacticus littoralis	58466	R′	37
Hemicyclops americanus, new species	[2] 58563 63420	do do	44
Labidocera aestiva	58452 58461 58485 58499 58519 58523 58551	G E Y 60-f. l. F A G	24
Labidocera wollastoni	58480	G	25
Macrosetella gracilis	58572	100-f. l.	38
Mecynocera clausii	58494	do	25
Metacyclops gracilis			46
Metridia lucens	58501	100-f. l.	25
Microsetella norvegica	58444 58459	E F	38
Microthalestris littoralis	58463	N′	38
Oithona brevicornis	58462 58510 58535	F H′ F	46
Oithona plumifera	58490	100-f. l.	49
Oithona similis	58486 58552	G F	49
Oithona spinirostris	58481	G	49
Oncaea minuta	58447 58505 58564	E 100-f. l. C	50
Oncaea venusta	5849 58533	100-f. l. do	50
Paracalanus parvus	58443 58518 58526	E 100-f. l. do	26
Pontella atlantica	58555	100-f. l.	26
Pontella meadii	58491 58554	do F	26
Pontella pennata, new species	58565 58567 [2] 58568 58566 63416	C do do 100-f. l.	27
Pseudocalanus elongatus	58467 58476 58500 58525	E Y 40-f. l. 100-f. l.	29

[2] Type specimen

TABLE 4.—*Specimens of copepods reported upon in this paper deposited in the United States National Museum, and index of species*—Continued

SPECIES	U. S. N. M. No.	STATION	PAGE
Pseudodiaptomus coronatus	58450	R′	30
	58475	Y	
	58507	A	
	58511	C	
	58570	G′	
Rhincalanus nasutus	58489	100-f. l.	32
Robertsonia chesapeakensis, new species	[2] 58561	T	39
	63418		
Sapphirina gemma	58517	100-f. l.	50
Sapphirina sinuicauda	58508	do	51
Tachidius littoralis			40
Temora discaudata			32
Temora longicornis	58451	G	32
	58456	do	
	58460	do	
Temora turbinata	58478	G	33
	58560	do	
	58465	F	
Tisbe furcata	58492	G′	41

[2] Type specimen.

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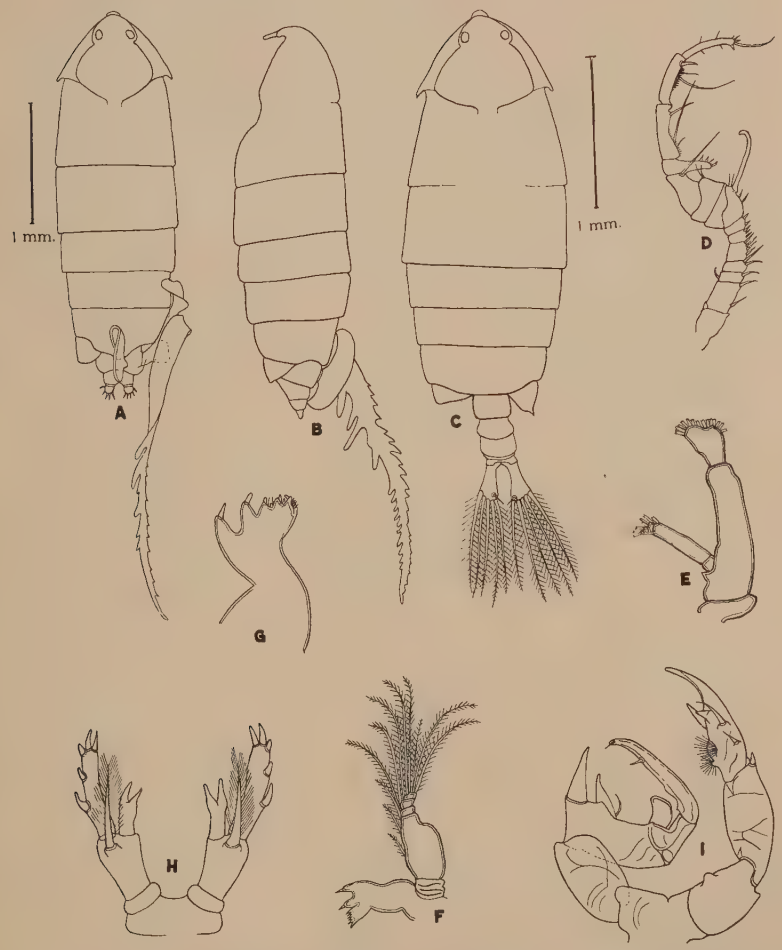
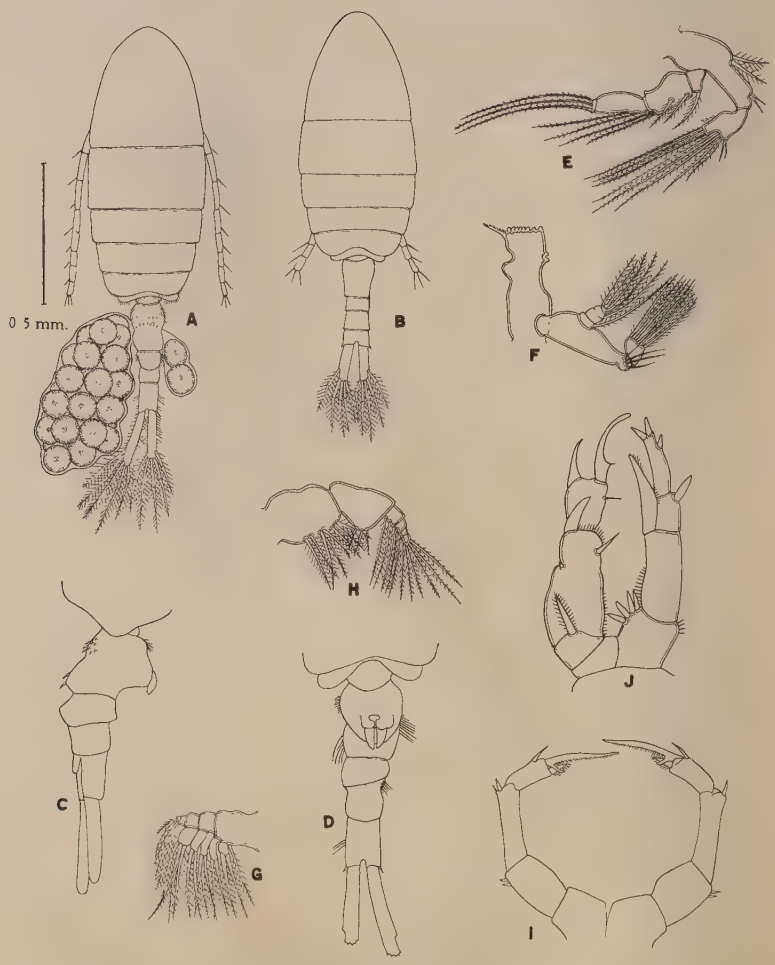


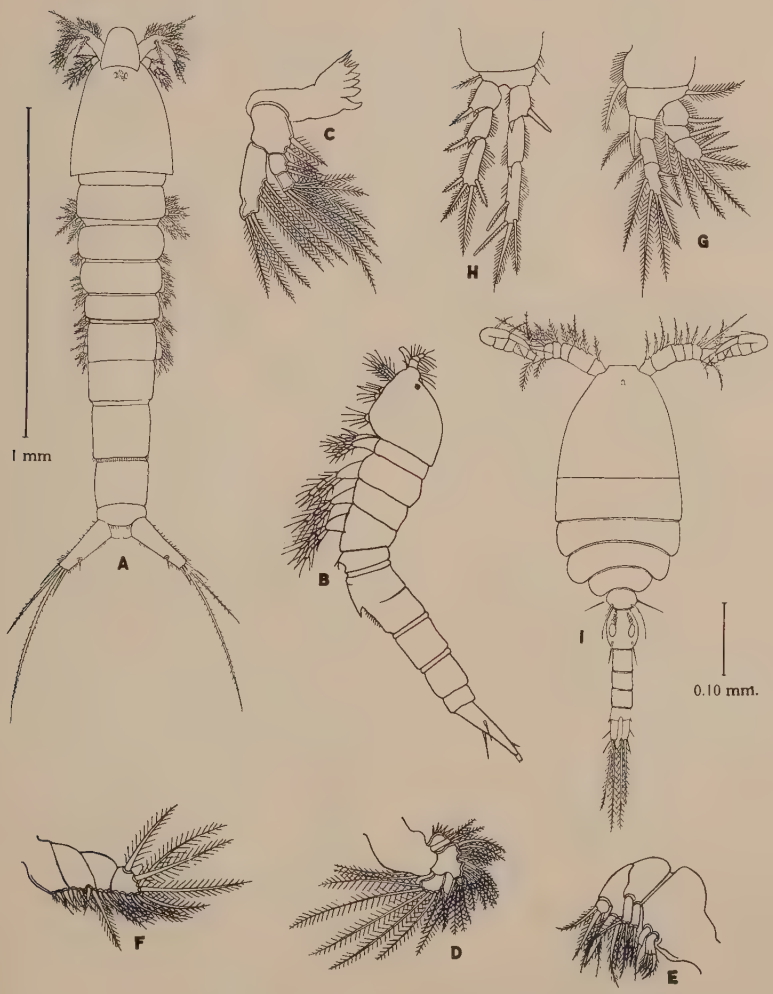
PONTELLA PENNATA

A, Dorsal view of female; B, side view of female; C, dorsal view of male; D, grasping antenna of male; E, second antenna of female; F, mandible and palp; G, mandible of male; H, fifth legs of female; I, fifth legs of male.



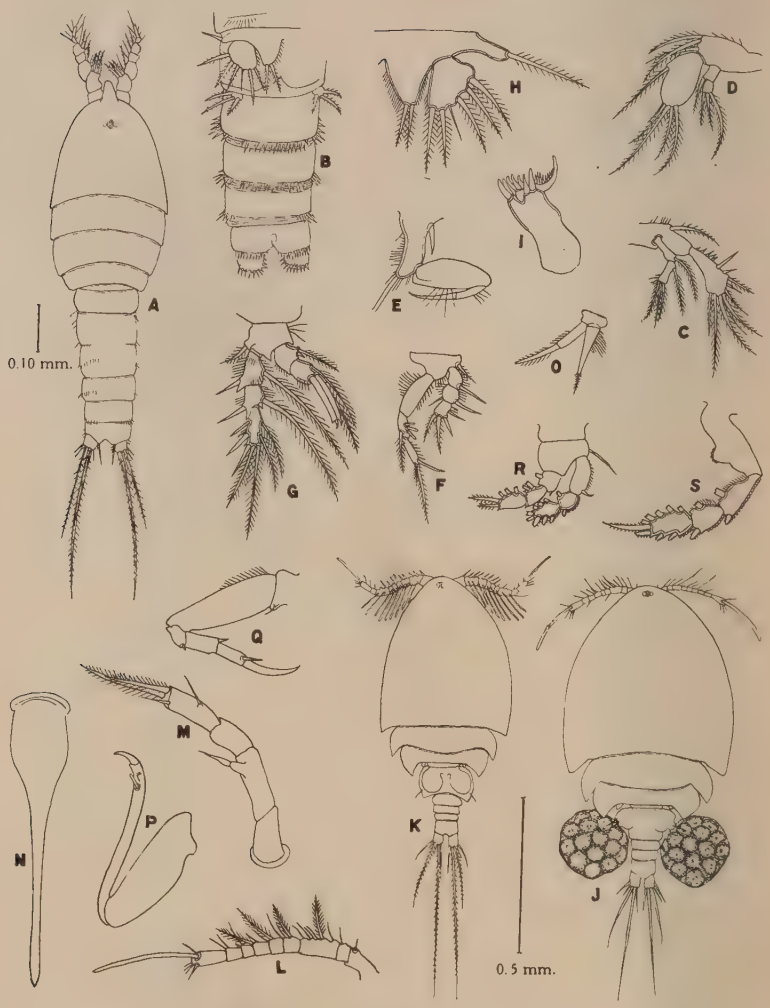
PSEUDODIAPTOMUS CORONATUS

A, Dorsal view of female; B, dorsal view of male; C, side view of posterior body of female; D, ventral view of posterior body showing asymmetry; E, second antenna; F, mandible and palp; G, second maxilla; H, maxilliped; I, fifth legs of female; J, fifth legs of male.



CANUELLA ELONGATA AND OITHONA BREVICORNIS

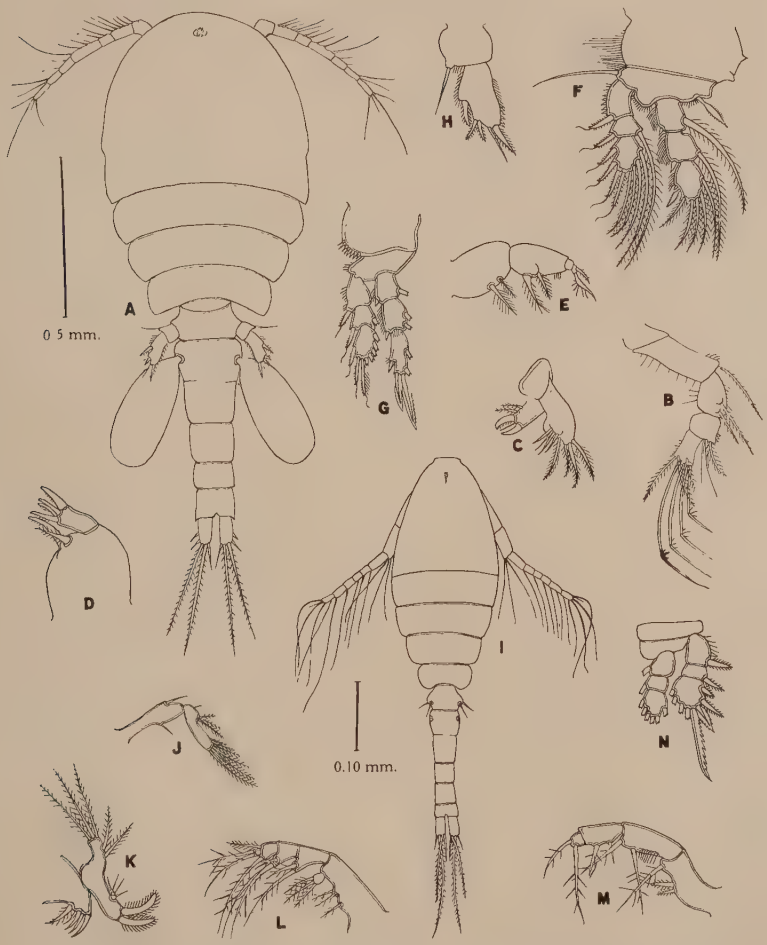
A–H, *Canuella elongata:* A, Dorsal view of female; B, side view of female; C, mandible and palp; D, first maxilla; F, maxilliped; G, first swimming leg; H, second swimming leg.
I, *Oithona brevicornis:* Dorsal view of male.



ROBERTSONIA CHESAPEAKENSIS AND CRYPTOPONTIUS GRACILIS

A–I, *Robertsonia chesapeakensis:* A, Dorsal view of female; B, ventral surface of posterior body showing rudimentary sixth legs and spines on posterior margins of segments; C, second antenna, D, mandibular palp; E, maxilliped; F, first swimming leg; G, second leg; H, fifth leg.

J–S, *Cryptopontius gracilis:* J, Dorsal view of female; K, dorsal view of male; L, first antenna of female; M, second antenna; N, mouth tube; O, first maxilla; P, second maxilla; Q, maxilliped; R, first swimming leg; S, fourth leg.



HEMICYCLOPS AMERICANUS AND OITHONA BREVICORNIS

A–H, *Hemicyclops americanus:* A, Dorsal view of female; B, second antenna; C, mandible and palp; D, second maxilla; E, maxilliped; F, first swimming leg; G, fourth leg; H, fifth leg. I–N, *Oithona brevicornis:* I, Dorsal view of female; J, second antenna; K, first maxilla; L, second maxilla; M, maxilliped; N, first swimming leg.